PENNSYLVANIA
GEOLOGICAL SURVEY
FOURTH SERIES

THE OIL AND GAS FIELDS OF PENNSYLVANIA

VOLUME I
INTRODUCTION

By

George H. Ashley and J. French Robinson

DEPARTMENT OF INTERNAL AFFAIRS
James F. Woodward, Secretary
BUREAU OF TOPOGRAPHIC AND GEOLOGICAL SURVEY
George H. Ashley, State Geologist
Harrisburg
1922

LETTER OF TRANSMITTAL.

Mr. James F. Woodward,

Secretary of Internal Affairs:

In accordance with Section 10 of the organic Act creating the Survey, I herewith transmit for your information and for publication, text and a map describing and delineating the oil and gas fields of the State. This is an introductory volume, to be followed by other volumes describing those fields in detail.

This volume forms part of my report to you giving "The Facts Obtained by the Survey" for the biennial period 1919-1921.

Respectfully,

GEO. H. ASHLEY,

State Geologist.

March 1921

TABLE OF CONTENTS.

	Page
Letter of Transmittal	3
Introduction	7
A new map of the oil and gas fields of Pennsylvania	7
Acknowledgments	7
The Origin and General Conditions of Accumulation of Oil and Gas	8
Composition	8
Derivation of oil and gas	8
Conditions determining the presence of oil or gas	9
Must be a supply of proper material	9
Conditions must be favorable for the preservation of the material	9
Partial distillation necessary	9
Distillation must be limited	10
A reservoir necessary	10
A cover or seal necessary	10
Pressure necessary	10
General Occurrence of Oil and Gas in Pennsylvania	11
Occurrence limited	11
Why oil lies west of gas	11
Relation between occurrence of oil and rank of coal	11
Local Conditions Affecting Occurrence of Oil and Gas	12
Oil pools and anticlines	12
Water, oil and gas in rocks	12
Structure of rocks	13
Determining factor in location of oil and gas pools	13
Structure contours explained	13
Irregularities of structure	14
Complicated conditions	14
Effect of pre-Pennsylvanian unconformity	14
Asymmetrical folding	15
Minor structural features	15
Irregularity of rock grain	16
The Oil and Gas Sands of Pennsylvania	16
Character and age of rocks	16
Sands not of uniform thickness	16
Names of sands	21
Table of sands	22
Structure of the Oil and Gas fields of Pennsylvania	24
Structure contours	24
How represented	24
How contours were obtained	24
Structure of Chestnut Ridge and eastward to the Allegheny front	24
Folding irregular	24
Structure west of Chestnut Ridge	25
The major syncline	25
Structure of northern half of fields	25
Production and Life of Oil and Gas Wells	25
General conditions	25
Proportion of productive wells	26

Page

Production per well 27
Life of wells 27
Use of rock pressures in determining the life and production of gas wells 27
Rock pressure explained 27
Calculation of gas reserves 29
Limitations of method 29
Spacing of wells Effect on life and production 31
Estimation of Reserves of Oil and Gas 32
Oil or gas obtainable by pumping 32
Federal Treasury Department method 32
Reserves of oil left in the ground after exhaustion by pumping 32
Outlook for Oil and Gas in Pennsylvania 33
General situation 33
Outlook for oil 33
Oil fields limited on east 34
Limits to northwest 34
Future oil from main field 34
Future production of present wells 34
What may be expected from new drilling 35
New oil pools 36
Rejuvenation of old fields 36
Outlook for gas 37
Exhausted gas pools 37
Life of present wells 37
Prospects for new drilling in (1) pools already developed 38
(2) New fields 39
Prospecting in the eastern part of the coal field 39
Outlook in northeastern counties of the State 41
Outlook in central and southeastern Pennsylvania 41
Summary 42
Chronological Data on Oil and Gas Development 42
Oil and Gas Production 45
Petroleum production 45
Natural gas production 45
Notes on the Oil and Gas Pools of Pennsylvania 47
Explanation of chart or table 47
List of abbreviations used 47
Short description of pools by counties 47
Erie County 47
Warren County 48
McKean County 48
Potter County 49
Tioga County 49
Crawford County 50
Mercer County 50
Venango County 50
Forest County 51
Elk County 52
Clinton County 52
Lawrence County 53
Beaver County 53
Butler County 54
Clarion County 56
Armstrong County 59
Jefferson County 60

Page
Indiana County 60
Cambria County 61
Washington County 61
Allegheny County 64
Westmoreland County 67
Greene County 68
Fayette County 71
References 72
Table of Oil and Gas Pools of Pennsylvania ..... (Placed on back of Plate I)

ILLUSTRATIONS.

Plate I. Map of oil and gas fields of Pennsylvania ..... (in pocket)
Plate II. Cross section from northwest to southeast across northern end of oil and gas fields 17
Plate III. Cross section from west to east from central Ohio to the Horseshoe curve at Altoona 18
Plate IV. Cross section from Erie to Altoona 19
Plate V. Cross section from northern West Virginia to Smethport, Pa 20

Figure 1. Effect of lack of parallelism in rocks 15
Figure 2. Effect of asymmetrical structure of anticline on position of axis 16
Figure 3. Production curves of selected oil wells (from Beall, C. H., The Decline and Ultimate Production of Oil Wells; U. S. Bureau of Mines Bulletin 177, 1919) 28
Figure 4. Production curves of selected gas wells 29
Figure 5. Curves showing decline of rock pressure in a number of fields 30
Figure 6. Group of wells in the Bradford field, Pennsylvania, showing the effects of compressed air from one well on oil and gas of surrounding wells 33
Figure 7. Map of part of Pennsylvania showing areas within which the coals have approximately equal fuel ratios 40
Figure 8. Curves showing the yearly production of petroleum in the world; the United States; California; Oklahoma; Pennsylvania; and the Bradford and McDonald pools in Pennsylvania 46
Figure 9. Map showing location of quadrangles 73

THE OIL AND GAS FIELDS OF PENNSYLVANIA

A PRELIMINARY MAP AND REPORT*

By
GEO. H. ASHLEY and J. FRENCH ROBINSON†

INTRODUCTION.

The rapidly increasing gap between the demand and supply of petroleum or "oil," and of natural gas, is reflected in rapidly increasing prices and in a renewed search for new supplies. To aid in the discovery of new supplies and prevent fruitless drilling in so far as possible, there is here presented a new sketch map of the oil and gas fields of Pennsylvania with descriptive notes.

It is planned that this preliminary report is to be followed by a series of more detailed reports. These will be of two kinds: (1) A series of reports, each covering a district of two or more counties, to consist essentially of the chapters on oil and gas from the reports on those counties; (2) the topographic and geologic atlas of the State published in quadrangle units. Each unit will have a map on the scale of one inch equals one mile on which are shown all of the oil and gas wells and such other data as can be shown on a map of that scale. This will be accompanied with such description as is necessary. These reports will correspond in a measure with the series of oil and gas bulletins already issued by the U. S. Geological Survey in cooperation with the State.

A NEW MAP OF THE OIL AND GAS FIELDS OF PENNSYLVANIA.

The accompanying map is the result of cooperation of the State Survey with the U. S. Geological Survey. The latter has been gathering data for such a map for many years under the immediate direction of G. B. Richardson and general direction of David White. To this data the State Survey has added certain data obtained by it, mainly as a result of a reconnaissance of the whole field by Mr. Robinson in the fall of 1920. The map includes the structure of several quadrangles not previously published; of these Mr. Richardson is responsible for the Zelienople, Butler, Somerset, and Windber quadrangles, and Mr. Robinson and Mr. R. W. Brown for the Pittsburgh and Greensburg quadrangles.

The new map shows the producing oil and gas fields of Pennsylvania; also some of the fields formerly productive which may be revived; and the structure of part of the fields, using brown contour lines (lines of equal elevation of a selected rock stratum) to indicate the structure. The structure as subsequently explained bears on the distribution of the oil and gas.

The use of the stippled pattern was found necessary because of the inability of the public printer to obtain transparent inks.

ACKNOWLEDGMENTS.

The writers wish to express their appreciation of the many favors granted them by the oil and gas companies of the State and by a multitude of individuals. The figures of production and drilling have in the main been taken from the reports of the U. S. Geological Survey and from the Oil City Derrick, to whom general acknowledgment is here made. Constant use has been made

*Because of congestion of public printing and in order that this report be completed at the earliest possible moment, it has been greatly shortened and condensed.

†Associate Geologist, resigned March 15, 1921.

of the reports of the Second Geological Survey of Pennsylvania and several hundred papers have been referred to in our study of the theoretic problems involved.

THE ORIGIN AND GENERAL CONDITIONS OF ACCUMULATION OF OIL AND GAS.

COMPOSITION.

Oil and gas are essentially complex compounds of carbon, hydrogen, oxygen and nitrogen. The exact proportion of these elements in any oil or gas can be determined by analysis, and it is possible by fractional distillation to drive off one after another, a large number of well known compounds, ranging from ether to vaseline, including gasoline, kerosene, benzine, toluene, and a great many others. Nevertheless, the exact combinations of these elements in the oil or gas are not known.

Crude oils of the United States vary in specific gravity from .800 to .880. The oils in rocks of greatest age and those most affected by folding are as a rule the lightest and correspondingly yield the largest percentage of the lighter distillates such as gasoline. The average specific gravity of seven samples of oil from Pennsylvania and New York obtained by the Bureau of Mines[1] was .813 (42.2° Baume) as compared with .809 (43.1°B) for West Virginia; .826 (39.5°B) for Western Ohio; .845 (35.7°B) for Illinois; .845 (36.7°B) for Oklahoma and .878 (29.5°B for California. The viscosity (Saybolt viscosity at 100° F.) of the corresponding samples gave 111, 110, 129, 148, 170, and 470. Pennsylvania crude oil when refined, according to the same authority, yields as follows:

Distillation of Pennsylvania crude oil compared with some other oils

Distillates	Pennsylvania		West Virginia		W. Ohio		Illinois		Oklahoma		California	
	%	B.	%	B.	%	B.	%	B.	%	B.	%	B.
Gasoline and Naptha	33.9	60.7	31.3	59.4	27.8	59.2	20.4	52.1	28.1	55.7	21.5	47.4
Kerosene	19.9	44.6	18.5	45.2	17.0	43.9	14.5	37.9	19.1	39.3	18.8	31.7
Gas and Oil	9.7	37.7	12.1	39.7	9.7	37.7	8.0	33.6	11.4	32.4		
Light lub. distillates	11.1	34.3	11.0	35.9	10.5	33.9	10.7	29.6	11.4	28.7	8.7	24.2
Medium lub. distillates	6.3	31.9	5.6	33.7	6.3	30.7	6.0	26.8	6.1	26.3	10.9	20.5

A typical analysis of natural gas used at Pittsburgh is as follows:[2]

Composition of Natural Gas of Pittsburgh.

Constituents	Per Cent.
Methane (CH_4),	84.7
Ethane (C_2H_6),	9.4
Propane (C_3H_8),	3.0
Butane (C_4H_{10}), chiefly,	1.3
Nitrogen (N_2),	1.6
	100.00

DERIVATION OF OIL AND GAS.

Oil and gas are generally believed to have been formed by the partial decomposition and transformation of plant and animal remains laid down in the rocks when the latter were deposited in the sea. There is much yet to be learned concerning the origin and accumulation of oil and gas, but during recent years, scores of trained observers have been comparing conditions all over the world where oil and gas have been found, seeking to find what is common to such places and what is common to areas where drilling has been fruitless. Their studies have involved microscopic and other investigations of the rocks in the oil and gas fields to determine possible sources of oil, laboratory experiments of all kinds to learn the physical conditions under which oil and gas will travel in rocks or will accumulate, calculation of all possible results under various assumed conditions and laboratory attempts to simulate the conditions found in nature.

[1]Dean, E. W., Properties of typical crude oils, etc., U. S. Bureau of Mines, Reports of Investigations, Serial No. 2202, 1921

[2]Burrell, G. A. and Robertson, I. W. The Compressibility of Natural Gas at High Pressure, Bureau of Mines, Tech. papers 131, p. 5, 1916.

CONDITIONS DETERMINING THE PRESENCE OF OIL AND GAS.

Must Be a Supply of Proper Material.—A primary condition for the formation of either oil or gas is an abundant supply of vegetable or animal material. This postulates a climate favorable to an abundance of life. Petroleum is thought to have been derived from the fatty parts of plants and animals—the cellulose of the plants and the nitrogenous tissues of the animals having probably been destroyed by bacteria in the early stages of decomposition. It has been suggested that oils with a paraffin base have come from vegetable fats and that oils with an asphaltic base have come from animal fats. Gas is usually considered as having been derived from the same sources as petroleum.

Conditions must be Favorable for Preservation of Material. A Second Condition.—A study of the rocks indicates that in the main the materials for oil and gas have been laid down in shallow marine or brackish water, where seaweed and other plant life were abundant and where sufficient mud was being washed in to steadily bury the debris accumulating on the sea bottom, so that decomposition was shut off before it had progressed too far. The result of these conditions is commonly a brown or black, bituminous shale. In places the mud washed in was a limy mud instead of a clay mud, and the resulting rock might then be a bituminous limestone. In California the principal source of the oil is a shale almost made up of the shells of microscopic plants known as diatoms, the oil coming from the decomposition of the diatom bodies. Rocks accumulated on the land or in fresh waters or in deep sea water are commonly without oil forming materials. Again, rocks accumulated where they are periodically exposed to the air and to weathering are commonly lacking in petroleum. Such rocks are rain-pitted and sun cracked, and are commonly red or reddish, yellowish or white. This condition rules out the large bodies of red beds in the State. Again, oil is commonly lacking in areas where drilling reveals a great and continuous thickness of limestone or sandstone. The failure of drilling in the Triassic (red beds) of southeastern Pennsylvania to find oil is in accord with results elsewhere, as almost no oil has been found anywhere in the world in rocks of that age.

Partial Distillation Necessary.—Third, there must be sufficient pressure or heat to produce a natural distillation of the plant or animal remains. A study of the oil shales of the west has shown an abundance of plant materials in a partly decayed condition. This material is now called "kerogen," and is believed to be the material from which most oil is derived. In the Devonian and Carboniferous black or brown shales of the States east of the Mississippi River, the kerogen consisted mainly of spores, which in the lower order of plants take the place of seeds. In the western shales the kerogen contains little or no oil, but will yield oil when heated, some layers yielding from one to two barrels of oil to the ton of shale. The eastern shales as a rule yield much less oil, because, it is believed, they have been subjected to much higher pressure and heat, so that part at least of the kerogen, has been converted into oil or gas which has escaped from the shale and accumulated in the larger pore spaces of coarse grained sandstones or "sands" as they are called by drillers.

This pressure and heat had three sources. The long continued weight of a great thickness of overlying rocks; the earth's heat acting in time on the deeply buried shales; the horizontal pressures that have resulted in folds in the rocks. The Devonian black shales that underlie a vast area east of the Mississippi River, including half or more of Pennsylvania, were buried to a depth of 6,000 feet in western Pennsylvania and 10,000 feet in central Pennsylvania. Furthermore, these shales were subjected to the almost inconceivable horizontal pressures necessary to buckle them into the great folds of Laurel, Chestnut and other ridges.

In the laboratory these shales yield oil when heated to temperatures of 900° to 1350° Fahrenheit, and gas if heated to a still higher temperature. Whether the black shales of Pennsylvania have been heated to such high tempera-

ture is not known. It is quite possible and probable that under the great pressures existing and the millions of years during which the shales were buried, oil would be formed at much lower temperatures.

Distillation Must Be Limited.—Fourth, the pressures and resulting heating must not have gone too far. It is well known that if coal be placed in a retort and highly heated, there remains coke, which contains little or no bituminous matter. If the temperature of the retort be somewhat lower, the residue may contain a little bituminous matter, about equivalent to that in "smokeless" coals. If bituminous, or oil shale be substituted for coal in the retort, the residue is called "spent shale" and will contain little or no bituminous matter, according to the temperature of distillation. Studies of the black or bituminous shales of Pennsylvania indicate that the black shales of central Pennsylvania are essentially "spent shales"; that is, the bituminous matter has all been driven out so they yield no oil on distillation. Shales from farther west show a gradually increasing amount of bituminous matter from east to west, the shales in Clearfield County yielding about five gallons of oil to the ton of shale, while shales in Beaver County yield as high as a barrel of oil to the ton.

Taking the world over, it is found that igneous rocks, that is, those that have been melted, and rocks so folded or crushed that they have been metamorphosed, contain no oil. In a metamorphosed rock, the original character of the rock has been changed. Often new minerals are formed because the heat has driven out of some of the clay or sandy materials the contained water of crystallization. In many places the bedding is distorted or destroyed and a new structure superimposed. It is also found that highly folded strata older than Cretaceous seldom contain oil, though in California as elsewhere, highly folded rocks of Cretaceous or later age may contain oil. Taking the world over, practically no oil has been found in rocks of Cambrian age. This is of interest in connection with the failure of wells in Pennsylvania to find oil in rocks of Cambrian age, the age of most of the rocks of southeastern Pennsylvania.

A Reservoir Necessary.—Fifth, there must be a "reservoir" in which the oil or gas may accumulate. Oil and gas do not occur in great cavities in the earth as many suppose, but in the open spaces between the grains of coarse grained sandstones, porous limestones or other rock. Experiments indicate that unless the pore spaces of a rock (as indicated by the amount of water the dried rock will absorb) constitute at least one-tenth of the total volume of the rock, oil, even though present, will not run into a well drilled into the rock. It is evident therefore, that if the oil remained in the shale in which it was formed, it would be extremely difficult to get it out. Fortunately, the capillary attraction of the surfaces of the rock grains toward water is about three times that toward oil, so that this is supposed to squeeze the oil out of the finer grained rocks and into the coarser grained rocks. The absence of such coarse grained rocks accounts for the lack of success in drilling in certain areas.

A Cover or Seal Necessary.—Sixth, this sandstone or "sand" must be so covered by fine grained rocks that any oil or gas contained in the sand cannot escape to the surface. If the edge of a rock containing oil is exposed to the air, and the oil is under pressure, it will gradually work its way out to the surface and escape. If the oil has an asphaltic base, as do the California oils, a deposit of asphalt or "brea" would gradually accumulate at the outcrop of the rock, where left by the evaporation of the lighter oils.

Pressure Necessary.—Seventh, there must be pressure of some sort both to separate the oil, gas and water, and to drive them into a well.

Recent experiments by Emmons and Thiel at the University of Minnesota, indicate that pressure of some sort is necessary if gas, oil and water in the rock shall separate according to their specific gravities. It is also generally recognized today that oil will run into a well only when there is pressure behind it to drive it in. This pressure may come from either gas or water, or it may be supplied artificially with compressed air, water or gas from gas wells. We know today the apparent giving out of many, if not of most

oil fields, is due more to the exhaustion of the gas pressure that forced the oil into the wells than to the exhaustion of the oil itself, and that by restoring the pressure the field may be revived. (The giving out of individual wells may be due to their becoming clogged with paraffin.) In this connection the belief is noted that only a relatively small part of the oil in a sand will flow into a well under normal conditions. Many fields in this and other States are taking on a new lease of life today, because the pressure has been restored by means of water or air pumped into the pool.

GENERAL OCCURRENCE OF OIL AND GAS IN PENNSYLVANIA.

Occurrence Limited.—The map published with this report shows that in so far as found, oil and gas occur in Pennsylvania in a relatively narrow band crossing the western half of the State from northeast to southwest. Having in mind the conditions just outlined as derived from a world wide study of oil and gas, it is possible to understand why most of the oil and gas of the State is confined to that relatively limited area. The State may be divided into four regions; (1) the bituminous coal field, lying west and north of the Allegheny Front, in which the rocks are gently folded, the folding dying out toward the west and north; (2) the central ridge and valley district, including the anthracite coal fields, in which the rocks are highly folded, and the bituminous matter in coals and shales largely driven out; (3) the Cumberland Valley region, underlain mainly by shale, limestone and sandstone, which are folded intensely, crushed, broken, and more or less metamorphosed, so that in places the shale is changed to slate, the limestone to marble, the sandstone to quartzite; (4) the southeastern districts, where the rocks are igneous or are ancient rocks altered to schists.

It is obvious that if the general conditions above outlined are true, that any oil and gas that may have existed in districts (2), (3) and (4), must have been driven out. That a little oil or gas may have remained, being protected by a bridging of the rocks, is doubtless true, as a number of gas springs and some oil springs are reported in those regions. Yet it remains true that drilling in those districts or in corresponding districts of other States has always been fruitless. Drilling in any of these districts in the light of past experience is, in the language of Wall Street, "bucking the tiger," that is, investing where there is one chance to win and a thousand to lose.

Why Oil Lies West of Gas.—Again, the general conditions of accumulation for oil and gas previously outlined help to explain the general distribution of oil and gas in the coal fields region. Remembering that the folding that has driven the oil and gas out of the rocks east of the Allegheny Front decreases gradually from east to west, will explain why oil is lacking in the counties nearest the front, and why gas is found in increasing volume toward the west, as the folding decreases in amount and intensity, corresponding to the steady increase in the percentage of gas or volatile matter in the coal of the same region. Reduced intensity of folding explains why the oil is confined to the western half of the oil and gas belt. The seeming lack of oil or gas in the northwestern counties of the State is due to the thinning out of the coarse grained sandstones in that direction and because nearly all of the rocks containing the oil and gas sands of other parts of the State, have risen to outcrop and are lacking along Lake Erie. All of the sandstones or other rocks in the western half of the State decrease in thickness from east to west. Thus of a round dozen productive sands east of Pittsburgh all but one—the Berea—disappear as productive sands before reaching the Ohio River at Steubenville, drillings showing no sandstone in the position of the lower sands or only "markers." Aside from these, drillings to a depth of 3,000 feet below the base of the Big Injun sand finds only shale.

Relation Between Occurrence of Oil and Rank of Coal.—An interesting relationship between the occurrence of oil and the percentage of gas in coal of the same region has been worked out by

David White, Chief Geologist of the U. S. Geological Survey. A study of coals in regions the world over where oil is also found, has shown that oil is confined to areas in which the coal contains no more than about twice as much fixed carbon as volatile matter. It has been long recognized that the difference between the high gas coals of western Pennsylvania, which contain almost as much gas (volatile matter) as fixed carbon, and anthracite in eastern Pennsylvania, which contains almost no gas, is due to the difference in the folding, and consequent heating, to which they have been subjected. The anthracite of Pennsylvania is in a region of intense folding. The "smokeless" coals of Clearfield and Cambria counties are in areas of less intense folding. The fixed carbon of these coals weighs from 3 to 5 times as much as the gas. The folding in the Beaver River area is very gentle. It is believed that this difference in the intensity of the folding from east to west, accounts for the presence of gas fields in Pennsylvania over a large area east of the oil fields, as shown on the maps.

LOCAL CONDITIONS AFFECTING OCCURRENCE OF OIL AND GAS.

OIL POOLS AND ANTICLINES.

While facts bearing on the general occurrence of oil and gas are of special interest to those living outside the present field of development, of even more interest to the industry are facts bearing on the local occurrence of oil and gas which aid in the locating of wells to secure the largest possible production and reduce to the minimum the business of drilling dry holes.

Early in the history of oil and gas drillers noted that successful wells often occurred in northeast-southwest lines and that by drilling to the northeast or southwest of good wells, the chances of success with new wells were increased. Geologists early noted that this direction agreed with the direction of the folds into which the rocks of western Pennsylvania had been forced at the time of the Applachian revolution. Little attention was paid to this until in 1883, I. C. White, State Geologist of West Virginia, pointing out that all of the great gas wells of Pennsylvania and West Virginia were close to the crest of one of the great rock waves or folds, or anticlines as the geologist calls them. Later he practically proved that the oil and gas follow the lines of folding, by developing an oil field along the whole length of the Burning Springs anticline in West Virginia, which ran not northeast and southwest, but almost due north and south. Since that time the general theory has gained wide acceptance and in modified form is the basis of the world wide search for oil and gas.

The relation between the rock structure and the occurrence of oil and gas may be well illustrated by the experience of drillers in the southwestern oil and gas fields. For example, K. C. Heald found that 88% of the anticlines and domes of the Osage Nation of Oklahoma are oil bearing, while only 15% of the troughs or synclines contain oil. F. G. Clapp has estimated that in nine townships of northern Oklahoma, success in drilling increased from 60% before geologic advice was sought, to 87% following geologic advice. Dorsey Hager has shown that of the new pools opened in Oklahoma between 1913 and 1917, 70% were found on geologic advice, one such wild cat well out of three finding oil as against one out of 150 drilled in the usual haphazard way. Hager also finds that out of 75 most important oil pools discovered in Oklahoma and Kansas between 1913 and 1917, all but four were on well defined structures such as domes, anticlines, and terraces.

The conditions in Pennsylvania are more variable and the results less favorable than in Oklahoma and the same success may not be counted upon; yet a knowledge of the principles involved should aid materially in the placing of successful wells.

WATER, OIL AND GAS IN ROCKS.

It may be recalled that drilling to a depth into the earth may find one or all three substances—gas, oil and water. Experience and experiments have shown that under certain circumstances,

which usually hold in the field, the three substances will separate and arrange themselves one above the other, according to their weight or specific gravity, the gas at the top, the water at the bottom. Whether the water in the rocks is a remnant of the original sea water entombed in the rock when deposited in the sea or water which has entered from the outcrop, is not always clear. This water is usually salty. It is abundant in some rocks and lacking in others. In general, it is lacking in the deeper seated rocks. In Pennsylvania little water is encountered at a depth of more than 3,000 feet. Likewise it may be noted that gas is more common than oil at these greater depths.

Experiment and experience has led to the belief that originally gas, oil and water occurred together in the rocks, but that as a result of the difference in the movement of the three substances through the rocks due to differences of surface tension and viscosity, the water has escaped from the deeper rocks and to a lesser degree the oil has followed. The surface tension of water is about three times that of oil. Further more, water is a so-called crystalloid, that is, a substance that will form crystals, while oil is a colloid or jelly-like substance. As is well known liquid substances will pass through a membrane, having no visible pores by a process called osmosis. Crystalloids will pass through a membrane, such as parchment paper, at a different rate from colloids, a fact which forms the basis of a method for separating the two. It is thought that by some such action the water has worked its way up through the fine grained cover rocks, leaving the oil and gas behind it and that similarly the oil has been separated from the gas, so that today very deep wells may find gas but no oil or water.

STRUCTURE OF ROCKS.

Determining Factor in Location of Oil and Gas Pools.—The factor that is mainly responsible for determining the position of oil and gas pools under the surface of the earth is the structure of the rocks. For eighty years or more, it has been recognized that the rocks of western Pennsylvania do not lie flat but form a series of long, narrow "basins" or synclines lying in a northeast-southwest direction, separated by equally long, narrow divides or anticlines. Some of the stronger anticlines coincide with prominent surface ridges, such as the Laurel Hill and Chestnut Hill ridges. Most of them, however, are not marked by any special surface features. Cross sections showing these folds were published in the final reports of the First Pennsylvania Geological Survey. They were mapped more in detail by the Second Pennsylvania Geological Survey. It was at that time thought that these folds ran nearly in straight lines and maintained uniform heights and depths. When under the Third or Commission Survey, the mapping of these folds in detail was undertaken, it was soon found that, in the main, the rock folds were anything but straight and regular. Instead, it was found that the shape, size, height and depth of the folds changed irregularly from place to place; there being wide and here narrow; here the anticline rose into a high, steep-sided dome, there it sank into a depressed saddle with gentle slopes. Again, in other places, two anticlines run together, pinching out the intermediate syncline or basin. Indeed, it was found as the west boundary of the State was approached, that the folding became very gentle and the directions of the folds most irregular, in places running at right angles to the general direction of folding.

Structure Contours Explained.—To represent all of these irregularities of the folding on a map clearly and accurately, structure contours are used. If it be supposed that all of the rocks above the Pittsburgh coal bed were lifted off and the Pittsburgh bed, where removed, were replaced, with the necessary underlying rocks, the structure would be represented by the undulating surface of the coal bed. If, now, western Pennsylvania were enclosed and water allowed to flow in until its surface stood 500 feet above sea level, it would fill in many basins in the southwest corner of the State. A line showing on a map the edge of the water against the coal bed would

be called a 500 foot contour line. If, next, more water were allowed to flow in until its surface stood at 600 feet above sea level, it would spread more widely in each basin and extend farther north east in some basins. The line on the map to show the position of the contact of the water and coal bed should now be called a 600 foot contour. Obviously by varying the height of the water contact, lines could be drawn that would represent the position of the surface of the Pittsburgh coal at any selected elevation above sea level. These contour lines may be shown for each 100 feet of elevation or, if greater detail is desired, for each 10 feet of elevation or for any other interval that might be selected, called the contour interval.

On the map accompanying this report the structure is represented by contour lines printed in brown, using a contour interval of 100 feet. The contour lines cover all of the areas surveyed in detail to date including several areas not previously published, the result of State work in 1920 or of work by the Federal Survey during earlier years. A little study will show that where the brown lines are close together the structural dip is steep and where they are far apart the dip is gentle or the rocks may even be flat. It is also evident that in going from contour line 1200 to contour line 1300, one is going up the dip and vice versa.

Irregularities of Structure.—Given a porous bed of sandstone containing gas, oil and water and folded into anticlines and synclines, it follows from what has previously been said that gas should be found on the anticlines, water in the synclines, and oil on the flanks. In Pennsylvania, however, the folds do not lie level but, as a rule, rise to the northeast, so that in the sands that are not entirely filled with water, the water level follows a zig-zag line extending northeastward into the synclines and turning back southwestward to where the adjoining anticline plunges below the water level. If oil occurs in the sand, it is obvious that it will occur just above the water and, therefore, on top of the anticlines just about where they go below water level, along the flanks of the anticlines further to the northeast and in the synclines still farther in that direction. Gas, if present, will occur on the anticline above the oil at the southwest but to the northeastward, where both the water and oil are below the elevation of the productive sand in the syncline, the gas may occur in both the anticlines and synclines. It is, therefore, clear that the typical relation of gas, oil and water to the structure is only partly true where the sand is not completely saturated with water. A few of the sands of Pennsylvania, such as the Salt sand and the Big Injun sand, appear to be filled with water wherever penetrated. Other sands appear to be water-free wherever penetrated except as water may have leaked in through faulty casing or plugging. Still other sands are water-bearing in some places and water-free in other places.

Complicated Conditions.—As any point within the oil and gas fields may be underlain by several sands, some saturated, some water-free and some with water conditions uncertain until pierced, it must be evident that elaborate general and local studies are necessary to determine the probable oil or gas conditions at any point. Up to the present, very little of such detailed study has been made of the Pennsylvania oil and gas fields.

Effect of pre-Pennsylvanian Unconformity.—The problem in Pennsylvania is further complicated by the existence of at least one marked unconformity between the surface rocks and the oil and gas bearing sands. Most of the oil and gas of the State comes from rocks lying below the coal measures. But before the coal measures were laid down in western Pennsylvania, there was a long period during which the rocks underneath the coal measures were lifted above water level and a considerable thickness washed away, so that the coal measures were laid down over the irregular surface of the older rocks.

In the anthracite region the Pottsville or basal coal measures have a thickness of 1350 feet; below is the Mauch Chunk shale 3,000 feet thick and the Pocono formation 1,100 to 1,400 feet thick. Western Pennsylvania was dry land dur-

ing the laying down of most of the Pottsville formation at the east so that only 100 to 300 feet of rocks representing the uppermost beds were deposited, and during the land period much or all of the Mauch Chunk was removed and in the northwestern counties much of the Pocono was washed away.

Because of the irregular surface upon which the coal measures were laid down, and because in the uplift which raised these underlying rocks above the sea level, they were slightly folded, the distance from the Pittsburgh coal bed to the oil and gas sands below the unconformity may change as much as 100 feet within 3 or 4 miles. As a result of this lack of parallelism between the beds at the surface and the oil and gas sands, the structure 2,000 or 3,000 feet under ground does not usually quite agree with that at the surface. The effect of this is shown in figure 1,

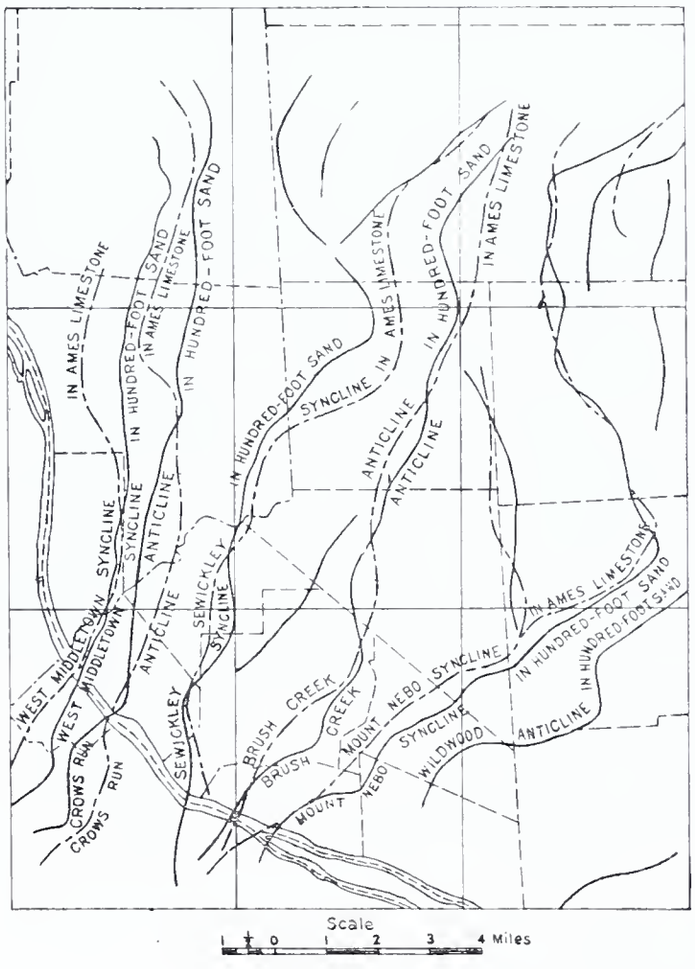


Fig. 1. Effect of lack of parallelism in rocks.

taken from the structure of the Sewickley quadrangle in which the solid lines show the position of the anticlines and synclines in the Hundred Foot sand and the broken lines the position of the anticlines and synclines on the Ames limestone, 1,600 feet above, which is exposed at the surface. It is quite possible that at least part of the difference in the position of the structure lines here and elsewhere, is due to the fact that in the folding the horizontal pressure from the surface downward has not been the same and that, regardless of the unconformity, the structure would have been different at the surface and at various depths.

Asymmetrical Folding.—Another element which may complicate conditions slightly is the lack of symmetry of the folds. If one side of a fold is steeper than the other, the axes at different points will lie, not in the vertical plane, but in a plane inclined in the direction of the lesser dip. If the dip on the east side of the anticline is 300 feet to the mile and 100 feet to the mile on the west side, the position of the axis at any depth will lie west of the axis at the surface. See Figure 2.

Minor Structural Features.—The map accompanying this report shows the structure on so small a scale that only 100 foot contours can be used and no details shown. The detailed reports are accompanied by maps which may show the structure down to 10 foot contours. When so shown, it is apparent that the flanks of the more gentle folds are not smooth and regular but like a rolling hill slope with structural benches, noses, and projecting ridges or depressed ravines. A careful study of the relation of oil and gas pools to these minor structural features indicates that oil or gas is more likely to be found in connection with one class of these structural features than elsewhere. It appears as if in its movement up or down a sloping bed, the oil or gas had stopped to rest at the top of any steep slopes or on the benches. For example, the McKeesport gas pool is at the point of a long nose in the Murrysville anticline. North of the pool is a broad structural flat while to the eastward, southward and westward are

long slopes. It is as though the gas creeping up the long slopes could not proceed across the flat to the northward.

IRREGULARITY OF ROCK GRAIN.

Finally, after every allowance has been made for water conditions and all of the elements involved in the structure, there remains the uncertain element of the irregular distribution of the open-grained rock. It has been found that in a bed of rock containing gas, oil and water, the gas and oil pools will be confined, in the main, to that portion of the rock in which the pore spaces are largest. Any one observing a large face of sandstone, as in a river bluff or a quarry, will usually discover that the average sandstone varies greatly in grain, and that areas of coarse, open-grained rock lie in streaks just as there are streaks of gravel and coarse sand running along a present day sea beach. So in the old rocks these streaks of coarse grain containing oil and gas commonly occur in parallel lines. If, therefore, the general direction of such a streak can be determined for any area, it may be of great help in determining the direction in which to drill new wells—the direction being taken from successful old wells.

The McKeesport pool was a good example of the effect of irregularity of rock grain. It was found that wells equally well placed as regards the structure, gave very unequal production. Long before development ceased, it became evident to most of those interested that the pool was limited on the east and west and had an oval shape, with the longer diameter nearly north and south and transverse to the axis of the anticline. In this instance it would seem clear that the limiting factor was the limited area of open-grained rock. Even within the limited area of open-grained rock there may be great differences in the grain of the rock, so that two wells close together may differ greatly in production. Thus at McKeesport "dry" wells were sunk directly between adjoining large producers. These variations of rock grain cannot be foreseen from the surface except where, as previously mentioned, it is possible to detect parallel streaks within which wells are good.

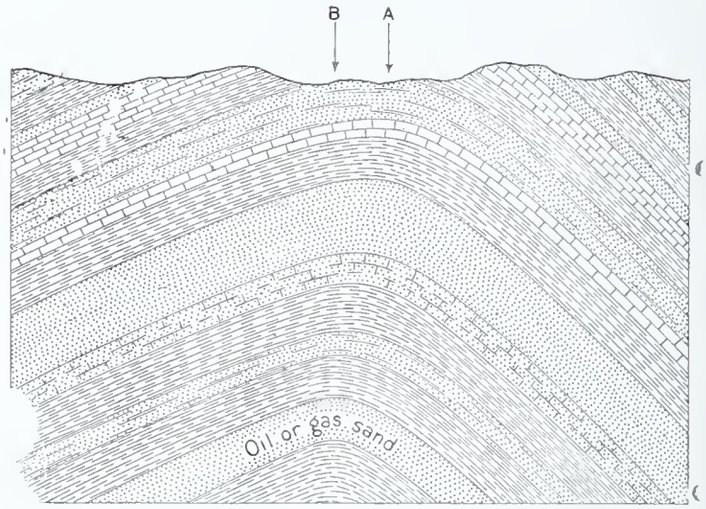
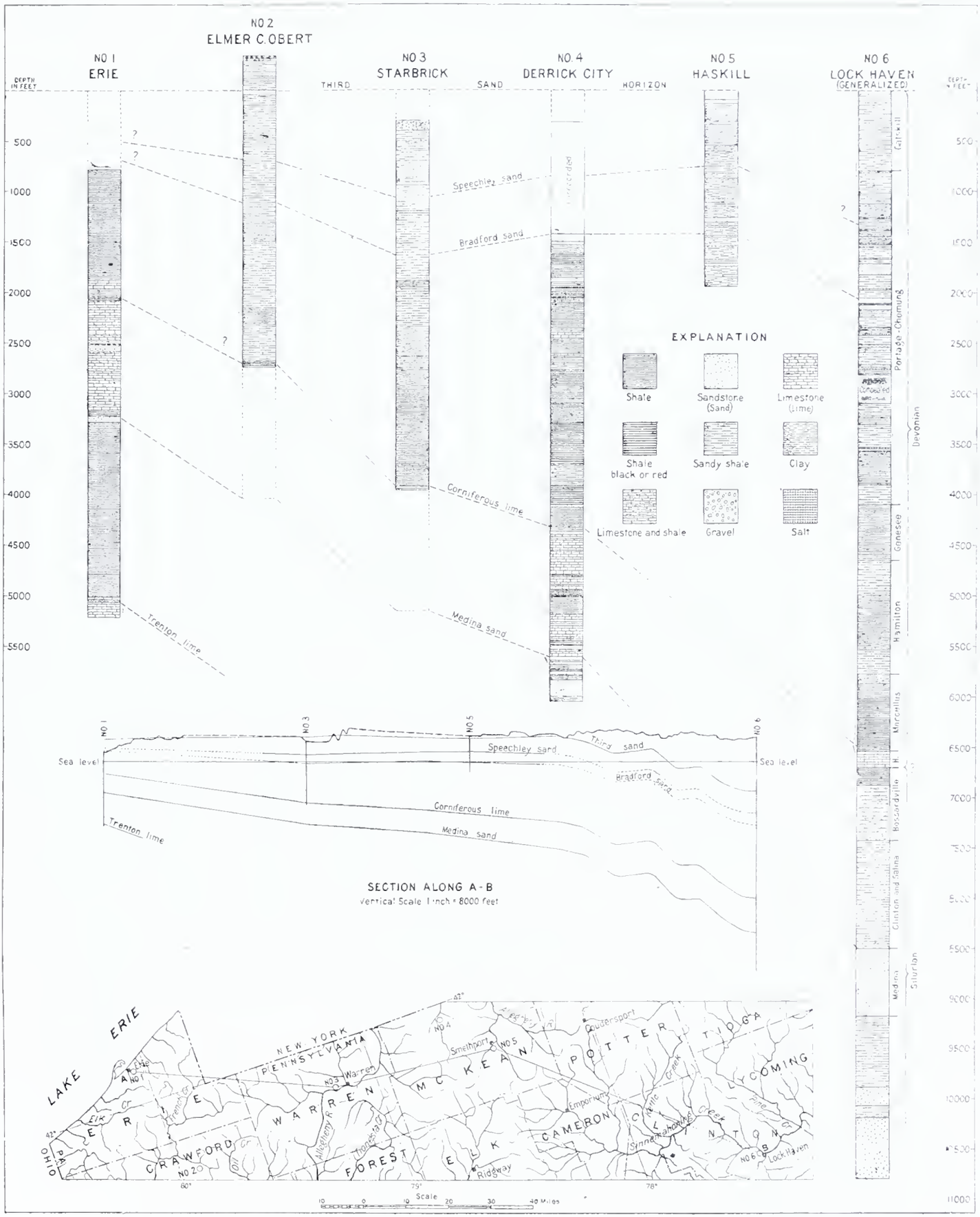


Fig. 2. Effect of asymmetrical structure of anticline on position of axis.

THE OIL AND GAS SANDS OF PENNSYLVANIA.

Character and Age of rocks.—Plates II. to V. give a series of sections of the rocks of western Pennsylvania. These rocks consist mainly of shales, sandstones, and thin limestones. The shales are mostly sandy and are in part black or red. The upper rocks belong to the Carboniferous age which included the coal measures and old "Lower Carboniferous" or, as these divisions are called today, the Pennsylvanian and Mississippian rocks. The lower rocks, including most of the oil and gas sands, are of Devonian age. The McDonald well reached into Silurian rocks and probably many future wells will enter these rocks, which are oil and gas bearing in Ohio and along Lake Erie.

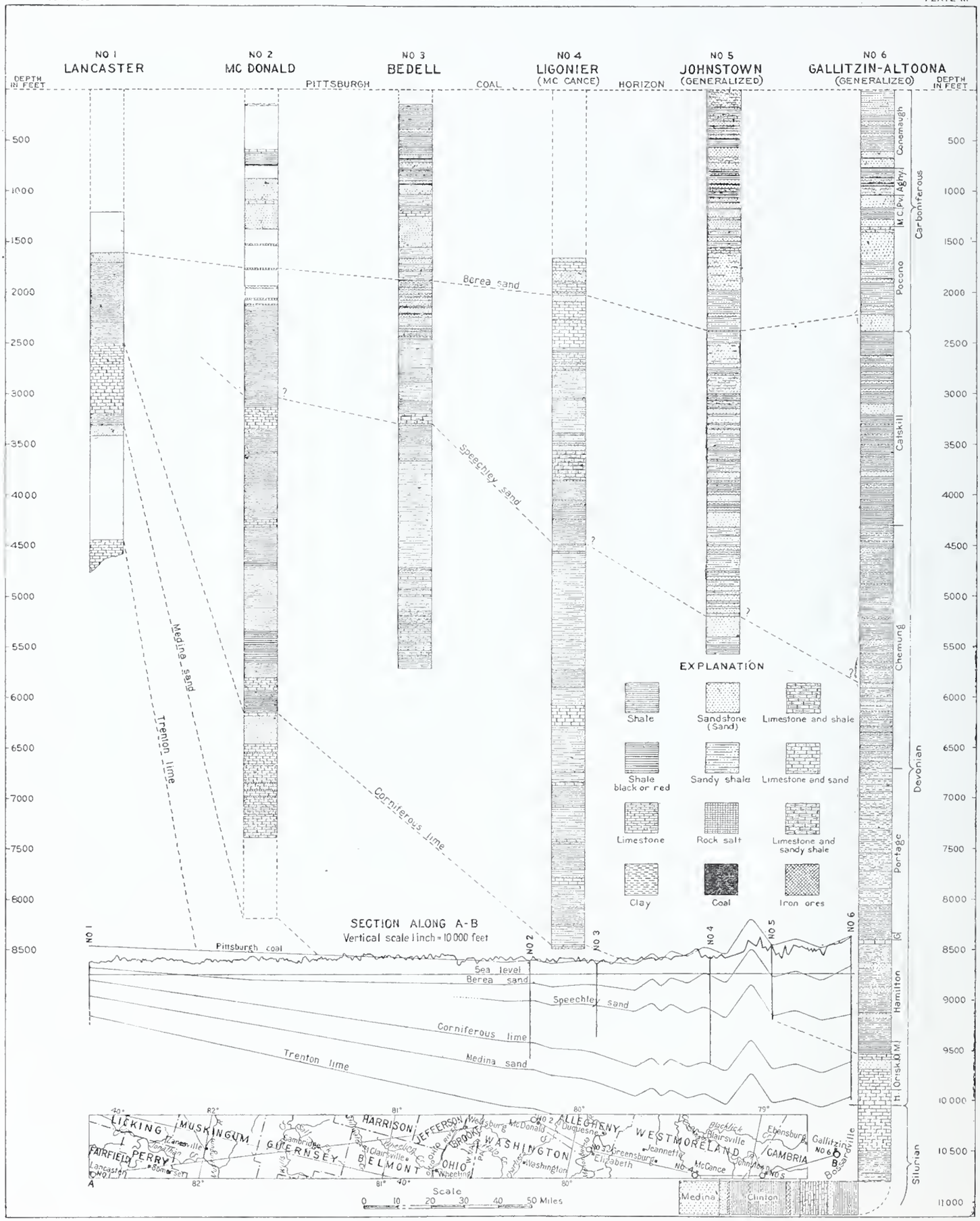
Sands Not of Uniform Thickness.—As shown by the sections, the rocks do not occur as wide spread beds of uniform thickness. Some of the sandstones are of wide extent and others are limited to a few square miles. The northwest-southeast lines of sections bring out the general fact that the sandstones thin from east to west, some of them thinning out entirely before reaching the western or northern edges of the State. The whole series of rocks containing oil and gas which are 4,800 feet thick in central Ohio are



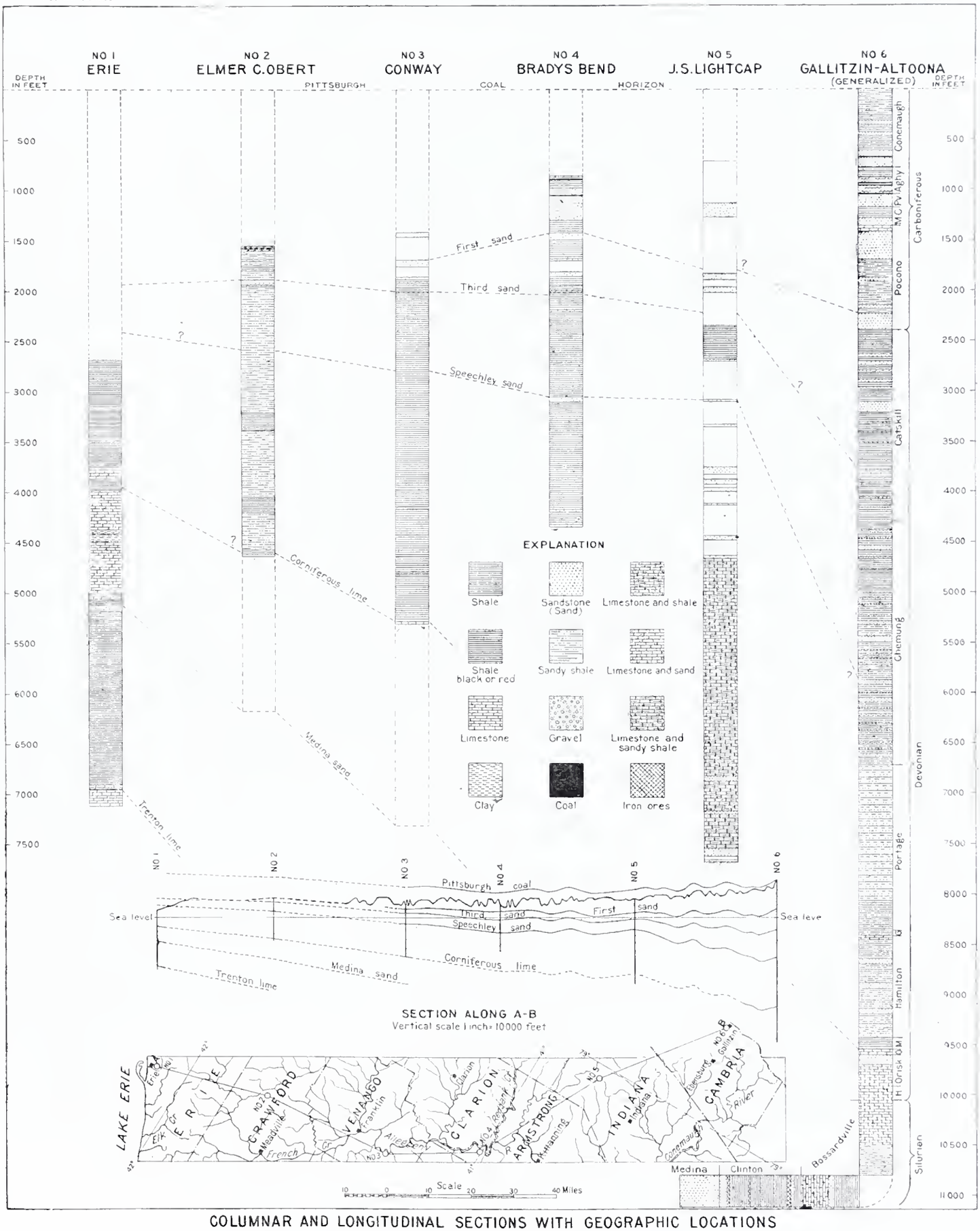
COLUMNAR AND LONGITUDINAL SECTIONS WITH GEOGRAPHIC LOCATIONS

STRUCTURE IN NORTHERN PENNSYLVANIA

THE OIL AND GAS FIELDS OF PENNSYLVANIA



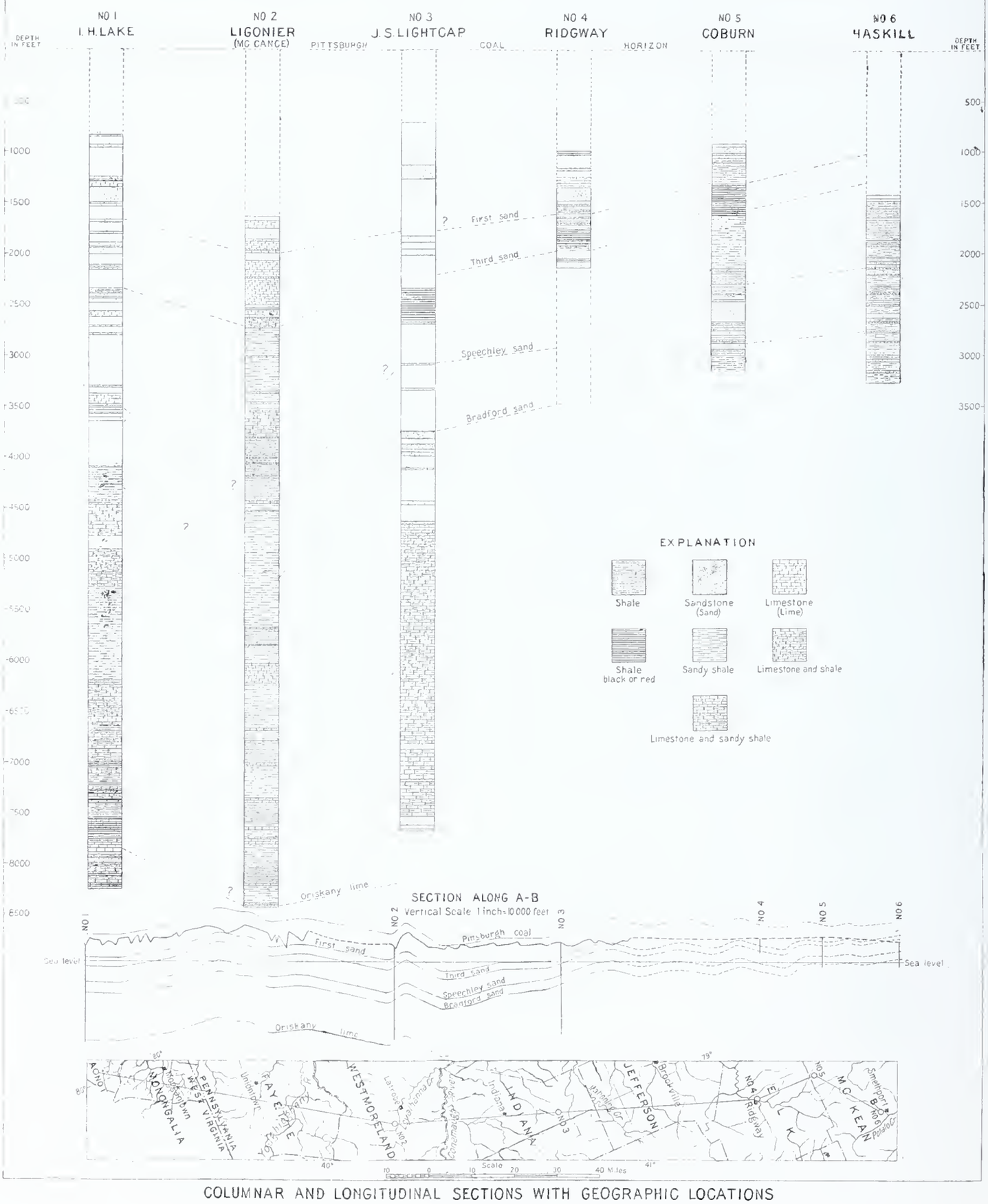
COLUMNAR AND LONGITUDINAL SECTIONS WITH GEOGRAPHIC LOCATIONS



COLUMNAR AND LONGITUDINAL SECTIONS WITH GEOGRAPHIC LOCATIONS

STRUCTURE FROM ERIE TO ALTOONA

THE OIL AND GAS FIELDS OF PENNSYLVANIA



COLUMNAR AND LONGITUDINAL SECTIONS WITH GEOGRAPHIC LOCATIONS

Table showing thinning of strata from East to West.
(Depth below Pittsburgh coal in feet)

	Cent. Ohio	E. Ohio	McDonald	Ligonier	Blair Co.
Pittsburgh coal	est.	0	0	0	est.
Top Big Injun sand	-----	1,000	1,100	1,650	2,000
Base Berea sand	1,600	1,600	1,700	2,700	3,250
Speechley sand	-----	----------	3,400	4,200	6,600
Oriskany sand	-----	----------	6,100	8,450	11,000
Medina sand	3,200	5,500 est.	8,300 est.	10,150 est.	13,600

13,600 feet thick in central Pennsylvania. Information is lacking as to whether this thinning takes place regularly from east to west. Comparing the sections on the Allegheny Front, in the Ligonier well and in the McDonald well, it would appear that the rate of thinning is a little more rapid at the east, so that the depths to the lower sands are not quite as great as they would be if the rate of thinning were uniform.

Names of Sands.—The more widely spread sandstones, many of which serve as reservoirs of oil or gas, have been given various names in various parts of the oil and gas fields, and still other names where they outcrop. The sandstone encountered by the Drake oil well has long been called the "First" oil sand. It is probably the same as the "Berea" sandstone of Ohio, and the "Murrysville"? or "Butler 30 Foot" sand of Allegheny and Butler counties. Below the "First" come the "Second" and "Third" oil sands of the northern oil fields. Similar names were used for the first, second and third oil sands encountered by the drill in other localities, some of which have since been found to be at very different horizons. To meet this condition, local names will be given in quotations after the correct name.

The following table gives the list of principal oil and gas horizons. It is not asserted, nor is it believed, that in all places the sands here listed as the same, represent identical beds of sandstone. That some of these sandstones occur at the same horizon over thousands of square miles seems certain, from tracings in the Allegheny River gorge and by tracing from well to well. That others are limited, especially from east to west, is equally certain. Where the sands are close together, as from the top of the Hundred Foot to the Elizabeth sand, it is probable that they represent varying lenses of a single thick sandstone formation. The names are here placed together only until detailed studies can determine their equivalence, or otherwise. The intervals given represent about the average on a line from Warren to Pittsburgh,—greater to the east and less to the west. The rate of increase is shown strikingly by comparing the depths to the Oriskany sandstone found in the McDonald and McCance wells and as computed for the same wells to the Tuscarora or Medina sandstone. The Trenton limestone is 4,100 feet below the Pittsburgh coal horizon in central Ohio and 15,400 feet below on the Allegheny Front in Blair County. It may therefore be calculated (assuming a uniform thickening), at 11,000 feet below the Pittsburgh coal at McDonald and 13,500 feet below under Chestnut Ridge.

TABLE OF PRINCIPAL OIL AND GAS SANDS OF PENNSYLVANIA.

System	Sub-system	Series	Formation	Name Where Outcropping	Drillers' Names	Average distance below Pittsburgh coal.
CARBONIFEROUS	PENNSYLVANIAN	PITTSBURGH	Monongahela	Pittsburgh coal.	Pittsburgh coal,	0
			Conemaugh	Morgantown sandstone.	"Murphy" sand,	150
				Saltsburg sandstone.	"Little Dunkard" sand,	325
				Mahoning sandstone.	"Big Dunkard" "Hurry Up" "Cow Run" sand.	500
			Allegheny	Upper Freeport coal.	Upper Freeport or "Connellsville" Coal,	630
				Freeport sandstone.	"Second Cow Run" sand,	680
				Vanport limestone.	"Ferriferous" limestone,	850
				Clarion sandstone.	"Gas" sand,	875
		POTTSVILLE	Beaver River	Homewood sandstone.	"Gas" sand,	930
				Conoquenessing sandstone.	"Salt" sand,	1,000
				Sharon (Olean) sandstone.	"Lower salt", "Maxon" sand,	1,100
	MISSISSIPPIAN	MAUCH CHUNK	Mauch Chunk	Greenbriar limestone.	"Little lime" "Mountain limestone",	1,225
				Red shale.	"Pencil cave",	
		POCONO	Burgoon	Loyalhanna limestone.	"Big Lime" "Keener" sand,	1,250
				Burgoon sandstone.	"Big Injun" or "Mountain" sand,	1,300
			Cuyahoga	Catton shale.	"Red shale",	
				Sharpsville sandstone.	"Squaw" sand,	1,630
				Sunbury shale.	"Papoose" sand,	
			Berea	Berea (Corry) sandstone.	"Berea", "First" of Venango Co. "Butler thirty foot" "Gas" "Salt" sand.	1,850

TABLE OF PRINCIPAL OIL AND GAS SANDS OF PENNSYLVANIA.

System.	Sub-system	Series.	Formation	Name Where Outcropping		Drillers' Names	Average distance below Pittsburgh coal.
DEVONIAN		JENNINGS	Catskill, phase of Chemung	Salamanca sandstone	(Venango oil group and Berea)	"Second" of Venango group" "Hundred foot" "Gantz" and Fifty foot" "Red Valley" (where split) sands,	2,000
						"Thirty foot" "Ninevah thirty foot",	2,150
						"Snee" "Blue Monday" "Boulder" "Stray-stray" "Hickory" sand,	2,180
						"Third stray" "Gordon stray" Campbell Run" sand,	2,260
						"Third" of Venango group, "Gordon" sand	2,350
						"Fourth" sand,	2,325
						"Fifth", "McDonald" sand,	2,400
						"Sixth", Bayard sand,	2,475
						"Elizabeth" sand,	2,550
			Chemung ?		(Warren oil group)	Warren "First" sand (local)	2,950
						Warren "Second" sand (local)	3,025
						"Specchley", "Glade", Warren "Third" sandstone,	3,200
						"Tiona" "Clarendon", Warren "Third" sand,	3,300
						"Gartland", "Balltown" "Cherry Grove" sandstone,	3,400
			Portage ?		(Bradford oil group)	"Sheffield", "Cooper" (?) sand,	3,600
						"Bradford", "Deer Lick" sand,	3,750
					(Elk oil group)	"Smethport", "Kane", "Elk group" etc. probably several horizons,	4,100
	Lower Devonian		Orisk.	Oriskany sandstone		Oriskany. (At Ligonier 8,450),	6,100
SILURIAN	ONTARIO		MEDINA	Tuscarora sandstone		Medina (At Ligonier 10,150),	8,300
						"Clinton sand" of Ohio.	

THE STRUCTURE OF THE OIL AND GAS FIELDS OF PENNSYLVANIA.

STRUCTURE CONTOURS.

How Represented.—The structure of much of the southern half of the oil and gas fields is shown by contour lines on the map. The contour interval of 100 feet means that there are ten lines for each 1,000 foot rise of the rocks. Each 500 foot line is made heavier. The structure of the northern half of the area is suggested by the axial lines as taken from the maps of the Second Pennsylvania Survey.

Unfortunately, the method of representation by contour lines does not set out the anticlines from the synclines, and while it is an accurate method of giving the facts, it is not as graphic and pictorial as might be wished. Attention may therefore be called to some of the features of the structure.

How Contours were Obtained.—The contours are drawn as on the Pittsburgh bed of coal. As a matter of fact, the Pittsburgh bed underlies only a small part of the area. Outside of that area the structure was originally determined in the field by using some lower bed of coal or limestone. The structure shown on the map was derived by adding to the contours as determined in the field in various areas, the vertical distance to the Pittsburgh coal from the key rock used in those areas. For example, in northern Allegheny County, the structure was originally mapped in the field by using the Ames limestone as the key rock. As in that area this limestone lies 300 feet below the Pittsburgh coal, 300 feet was added to the elevations of the contours to bring them up to the horizon of the Pittsburgh bed. In the eastern part of the area the contouring as originally prepared or published was on the Upper Freeport or Lower Freeport or Upper Kittanning coal beds as key rocks. The contours in each area were therefore raised by an amount equal to the vertical distance from the Pittsburgh coal to the key horizon used. Unfortunately, this interval does not remain constant, but increases toward the east. Thus, the interval from the Pittsburgh coal to the Upper Freeport coal increases from about 600 feet in the Latrobe area to nearly 900 feet north of Somerset. These changing intervals have made necessary the recalculation of the contours and may make the structure appear a little different from that originally published.

STRUCTURE OF CHESTNUT RIDGE AND EASTWARD TO THE "ALLEGHENY FRONT"

Viewing the structure as a whole, it will be noticed that the rocks in the southeastern part of the area are more closely folded than those further west, and are correspondingly lacking in oil and gas. In this southeastern area there are three principal anticlines corresponding to the three principal ridges. These, with the intermediate ridges constitute what are commonly called the Allegheny Mountains. The three ridges are, beginning at the east: The Allegheny Mountain or Allegheny Front; Laurel Ridge, and, at the west, Chestnut Ridge. Between these principal axes are several minor axes, which are less regular than the major axes, running together in some places and pinching out in others. The main axes themselves are not as regular as was thought earlier. A spur sets off from the Chestnut Ridge anticline in eastern Fayette County, and the elevation of the Pittsburgh coal along the axis decreases from 4,200 feet to 3,000 feet within ten miles. Laurel Ridge anticline nearly fades out in southern Clearfield County and northeast of Osceola and Philipsburg is so involved with faulting that its exact position is difficult to determine.

Folding Irregular.—None of the folds follow straight lines nor do they run in parallel lines in their winding courses. Two adjoining anticlines may be close together in one area and far apart in another. The height of the anticlines and the depth of the synclines is very inconstant. Most of the anticlines present a succession of elongated domes separated by saddles like a row of potato hills, and the synclines are likewise commonly a succession of deep basins separated by shallow saddles. In places the domes of the

anticlines and the basins of the synclines lie side by side and elsewhere they may alternate, a dome of an anticline coming beside the saddle of a syncline. As yet, no definite system of domes or basins has been worked out, nor are any pronounced cross folds apparent.

STRUCTURE WEST OF CHESTNUT RIDGE.

West of the Chestnut Ridge the rocks are less closely folded, the folds becoming more open and gentle westwardly, until in most of Greene, Washington, Beaver, Butler and western Allegheny counties, the folding is so slight that a spirit level is required to detect and measure it. In this area of gentle folding detailed studies show that the structural lines run very irregularly, with some rather prominent cross folding, that is, folding in which the main axis does not lie from northeast to southwest.

THE MAJOR SYNCLINE.

In the third place, if the actual or computed elevations of the Pittsburgh coal bed in different areas, as recorded in the structure contour lines, are compared, it is evident that the anticlines or synclines are imposed on the flanks of a major syncline or basin, which includes all of the area here discussed. Thus, in northern Somerset County the Pittsburgh coal horizon is everywhere more than 2,400 feet above sea level, rising to over 4,000 feet on the anticlines. From this, the general elevation decreases to the westward to a minimum along the axis of the Ninevah syncline in the southwestern corner of the State, where it is down nearly to sea level. From this lowest point it rises along the axis of the syncline to an elevation of 1,000 feet at Pittsburgh.

West and north of Pittsburgh in northern Washington County, Beaver and Lawrence counties and northwestern Butler county and presumably to the north of this area, the rocks have a fairly uniform rise to the north. While the contour lines do not run straight east and west, the dip is so gentle and, on the whole, so fairly even, that only by detailed accurate leveling can the structure be used in determining where to drill within that area.

STRUCTURE OF NORTERHN HALF OF FIELDS.

The only detailed structural mapping in the northern half of the area, has been in the Foxburg-Clarion district, the Warren district and in the Gaines-Elkland-Tioga district. Most of the rest of that part of the field is as yet lacking in topographic maps. Such mapping has been started in the Oil City, Tionesta, Brookville and Reynoldsville areas and should be completed in 1922. Detailed oil and gas studies cannot be made economically in these areas until the topographic maps are available.

PRODUCTION AND LIFE OF OIL AND GAS WELLS.

GENERAL CONDITIONS.

Questions of first importance to men proposing to drill for oil or gas or to invest in oil or gas development are, what are the chances of getting a producing well; what is the amount of production necessary to recover the cost, and, what will be the probable life and total production of wells.

The search for oil and gas may be made a regular legitimate business, assuring as steady an income as any other line of business, or it may become a gamble pure and simple. In order that it may not be a gamble, account must be taken of all of the factors mentioned, above.

It is assumed that everybody knows that a percentage of all wells drilled are "dry" or have failed to find either oil or gas; that the production of a producing well starts out with a large initial flow which declines rapidly at first but more and more slowly as time goes on; that all wells have a limited life which may be a few months only or may be 30 or 40 years; that if a given production is to be maintained, a certain number of new productive wells must be drilled in each year.

It may not be so generally known that gas wells once productive and later exhausted by the use of vacuum pumps cannot be renewed, but that oil wells that appear to be exhausted may,

usually be renewed by the removal of the paraffin that commonly tends to clog the well or by renewing the pressure back of the oil. It is not an uncommon experience to have a new well drilled between two old oil wells already exhausted or approaching exhaustion, start with a flow equal to the initial flow of the old wells.

PROPORTION OF PRODUCTIVE WELLS.

Reference has already been made to statistics from Oklahoma that wild cat drilling for oil without geologic advice is successful on the average in only one out of 150 holes, while wild cat drilling with geologic advice may on the average count on one successful hole in three drilled. Drilling in proven fields is much safer. Yet even here the number of dry holes is always a large percentage of those drilled. For example, in December 1920, of 43 holes drilled in the southwestern district of Pennsylvania, 18 were dry, or 41%. On the other hand, of 67 wells drilled in the Bradford field during the same month, only one was dry. The Bradford field is almost unique in the high percentage of productive holes. Taking the State as a whole, the figures show: That of 2602 holes drilled in Pennsylvania in 1914, 2281 were productive and 321 dry; of 1808 drilled in 1915, 1528 were productive and 280 dry; of 2276 drilled in 1916, 1989 were productive and 287 were dry; of 2376 drilled in 1917, 2024 were productive and 252 dry; of 1827 drilled in 1918, 1615 were productive and 212 dry. This gives an average of 13% for dry holes. That this small percentage of dry holes does not hold good over the whole field is better shown by the following record of drilling from 1915 to 1918 inclusive:

Record of wells drilled in Pennsylvania, 1915-1918.

Year.	1915			1916			1917			1918		
	Oil.	Gas.	Dry.	Oil.	Gas.	Dry.	Oil.	Gas.	Dry.	Oil.	Gas.	Dry.
Bradford	313	24	11	485	13	11	443	16	10	472	1	15
Middle	159	7	16	230	12	20	219	35	34	169	36	30
Venango—Clarion	458	71	66	955	67	83	644	42	82	466	28	25
Butler—Armstrong	224	16	84	239	43	57	168	33	62	88	14	26
Southwest	179	77	103	385	111	116	302	122	164	198	123	90
Total	1,333	195	280	2,204	246	287	1,776	248	325	1,396	202	212
Total	1,808			2,827			2,379			1837		

The record of wells drilled for gas from 1910 to 1916 is as follows:

Years,	1910	1911	1912	1913	1914	1915	1916
Gas wells	857	832	993	1011	998	863	1009
Dry holes	161	224	219	259	236	188	252

Here are some of the figures for one company, a company which does very little wild catting:

Peoples Natural Gas Co.

Years,	1911	1913	1915	1917
Producing	30	75	53	131
Dry	11	8	4	43

These figures indicate that a company starting to drill for oil or gas in Pennsylvania should at once charge off the cost of at least one well in three, and much more if wild catting.

From these figures it is obvious that a person, partnership, or corporation proposing to drill only a single well or a small number of wells, stands a chance of getting only dry holes or such a small number of productive wells as possibly not to pay for the cost of drilling. On the other hand, a company which drills many wells during a year and does such drilling upon adequate geologic information, should secure a sufficient number of producing wells to make the business a paying one, provided, of course, that ordinary business foresight is used and good business methods are employed.

PRODUCTION PER WELL.

Then comes the question of the production per well. The production of wells may be stated in three ways: As the initial or first day's production; as the present daily production, or as the daily production for the current year. The following table gives the average initial production of oil per well by months for the several districts of Pennsylvania during 1920 (taken from "The Oil City Derrick"):

Average initial production of oil wells in Pennsylvania in 1920, in barrels.

Fields	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bradford	2.5	3.0	2.4	2.5	2.3	2.6	2.2	3.0	3.1	3.3	2.6	2.4
Middle	1.1	1.6	1.2	1.2	1.6	1.2	1.7	1.1	1.2	1.7	1.3	1.5
Venango—Clarion	1.0	1.3	1.9	1.4	1.7	1.9	1.5	1.3	2.1	1.4	1.5	1.9
Butler—Armstrong	2.9	5.0	9.4	2.7	3.0	3.1	2.2	6.3	3.2	3.3	3.3	4.2
Southwest	4.8	9.2	11.4	5.6	8.9	9.0	14.6	11.4	19.9	47.6	3.1	4.4

The effect of a large oil well in Greene County which came in in October can be observed in the table. Many moderately sized wells came in during the year, but it will be observed that most of the new wells in this State started with initial productions of between one and five barrels.

The following table shows the average initial daily open flow per well of producing gas wells of several companies operating in Pennsylvania and West Virginia. Where all wells are included it will be found that the high initial production comes largely from old wells still flowing but which had high initial productions when drilled in.

Average initial daily open flow of gas wells, in cubic feet.

		1911	1913	1915	1917
People Nat. Gas Co.	(all well)	830,000	730,000	1,160,000	670,000
Potter Gas Co.	(new wells)			262,000	195,000
Mountain Gas Co.	(new well)				135,000
Penna. Gas Co.	(new wells)	860,000	226,000	850,000	275,000
United Gas Co.	(new well)	680,000	370,000	330,000	275,000
Hope Nat. Gas Co.	(all wells)		580,000	410,000	340,000
	Average for 1917 (not weighted)				315,000

LIFE OF WELLS.

It is well known that oil and gas wells do not flow indefinitely, but that starting with a maximum or nearly maximum initial flow, they at first, commonly drop off rapidly then more and more slowly until the production has reached a settled flow, when the decline may become very slow.

In 1917 there were reported by the U. S. Geological Survey to be in Pennsylvania 58,417 productive oil wells. The production of oil in the State for that year was 7,733,200 barrels, or less than one third of a barrel a day.

At the end of 1918 there were reported to be 15,294 producing gas wells in Pennsylvania. During that year these wells produced 133,397,206,000 cubic feet, or roundly 8.4 million cubic feet per well for the year, or less than 23,000 cubic feet a day.

The life of oil and gas wells can thus be shown by curves on cross section paper in which the horizontal ordinates stand for time and the vertical for production. In figure 3 the production of a selected group of typical oil wells is shown by curves.

Notice the rapid decline in the early months and the slow decline after the well has reached settled production.

In figure 4 are shown curves of selected typical gas wells, including a well at McKeesport (not the "Big" well), and a well in the Cleveland field that, like the McKeesport pool, was a town lot development and, therefore, overdrilled.

USE OF ROCK PRESSURES IN DETERMINING LIFE AND PRODUCTION OF GAS WELLS.

Rock Pressure Explained.—Gas in the rock is commonly highly compressed. The amount of

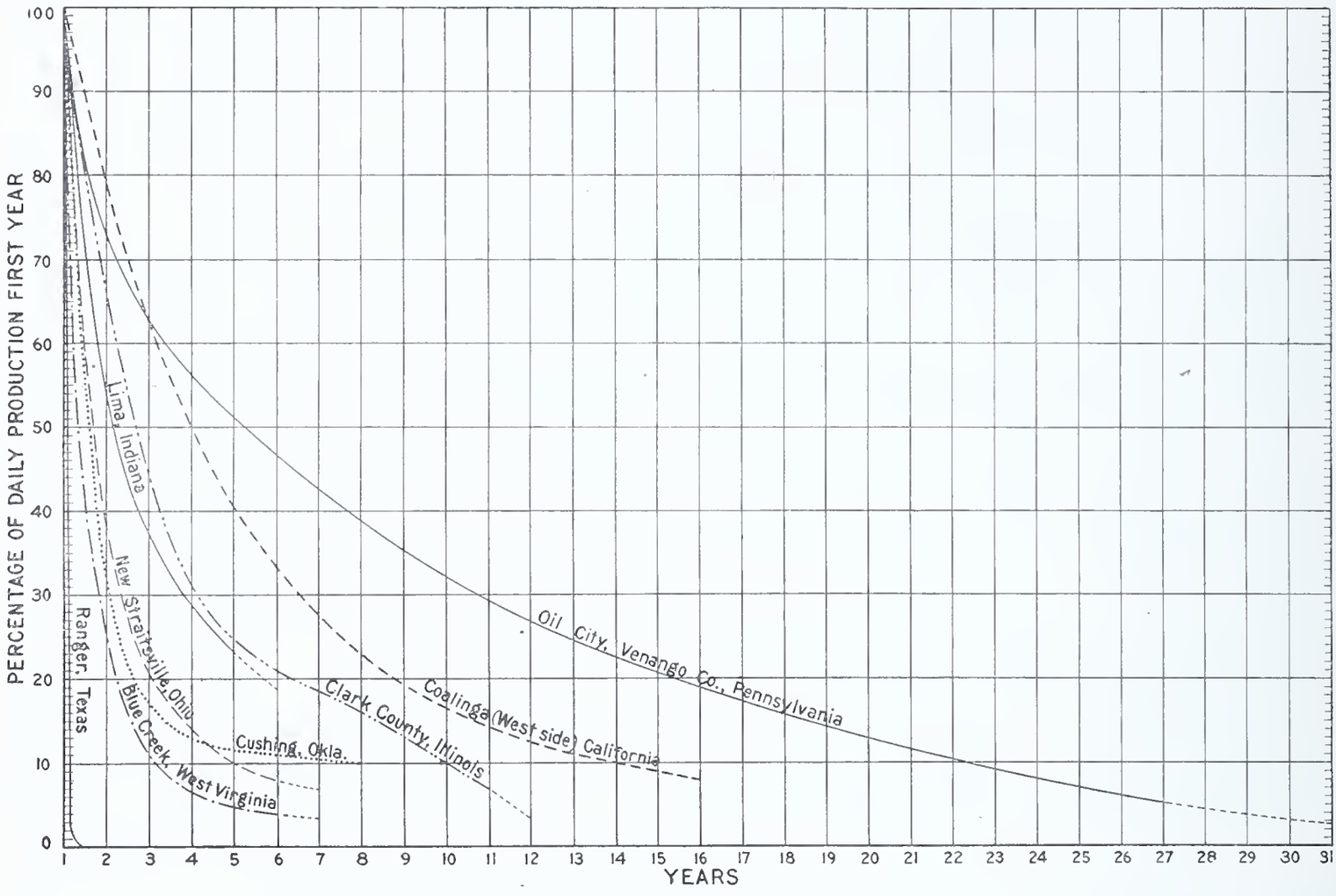


Fig. 3 Production curves of selected oil wells. (from U. S. Bureau of Mines Bull. 177.)

this compression can be determined by measuring the pressure with a gauge at the mouth of the well when the latter is closed in. This pressure is called rock pressure. Rock pressure, combined with well flow for a given period, gives a fairly accurate method for measuring the capacity of a gas well. If 1,000 cubic feet of natural gas at atmospheoric pressure (14.6 lbs. square inch), be compressed to 100 cubic feet or 1-10 its original volume, its pressure will be increased approximately 10 times or to 146 pounds per square inch. If it be further compressed until the original 100 cubic feet fills only one cubic foot or 1-100 of the original volume, the pressure of the gas against the sides of the containing vessel will increase to approximately 1,460 pounds per square inch. This relation expressed as a law is known as Boyle's Law. If natural gas were a perfect gas, this would be exactly true, according to Boyle's law; but natural gas consists of a variety of gases and of some vapors. Some of these vapors would, doubtless, be compressed to liquids under a pressure of 1460 pounds and other gases, it is known, do not follow strictly the law. For these reasons natural gas will occupy less space for any given pressure above atmospheric pressure than it should according to Boyle's law. Thus methane has been found to be 9% more compressible at 40 atmospheres and about 17% more compressible at 100 atmospheres than at one atmosphere*. One cubic foot of methane under a pressure of 1,460 pounds would, therefore, expand to 1,170 cubic feet at atmosphere pressure instead of to 1,000 cubic feet. Natural gas, as a whole, is still more compressible at high pressures. Experiments at Pittsburgh have shown that the natural gas used there will occupy only 85% of its theoretical volume when under pressure of about 500 pounds per square inch.†

*Landolte and Bornstein, Physikalisch-Chemische Tabellen, 1905, p. 65.
†Burrell, G. A. and Robertson, I. W., Bureau ofMines, Tech. Paper 131, p. 9, 1916

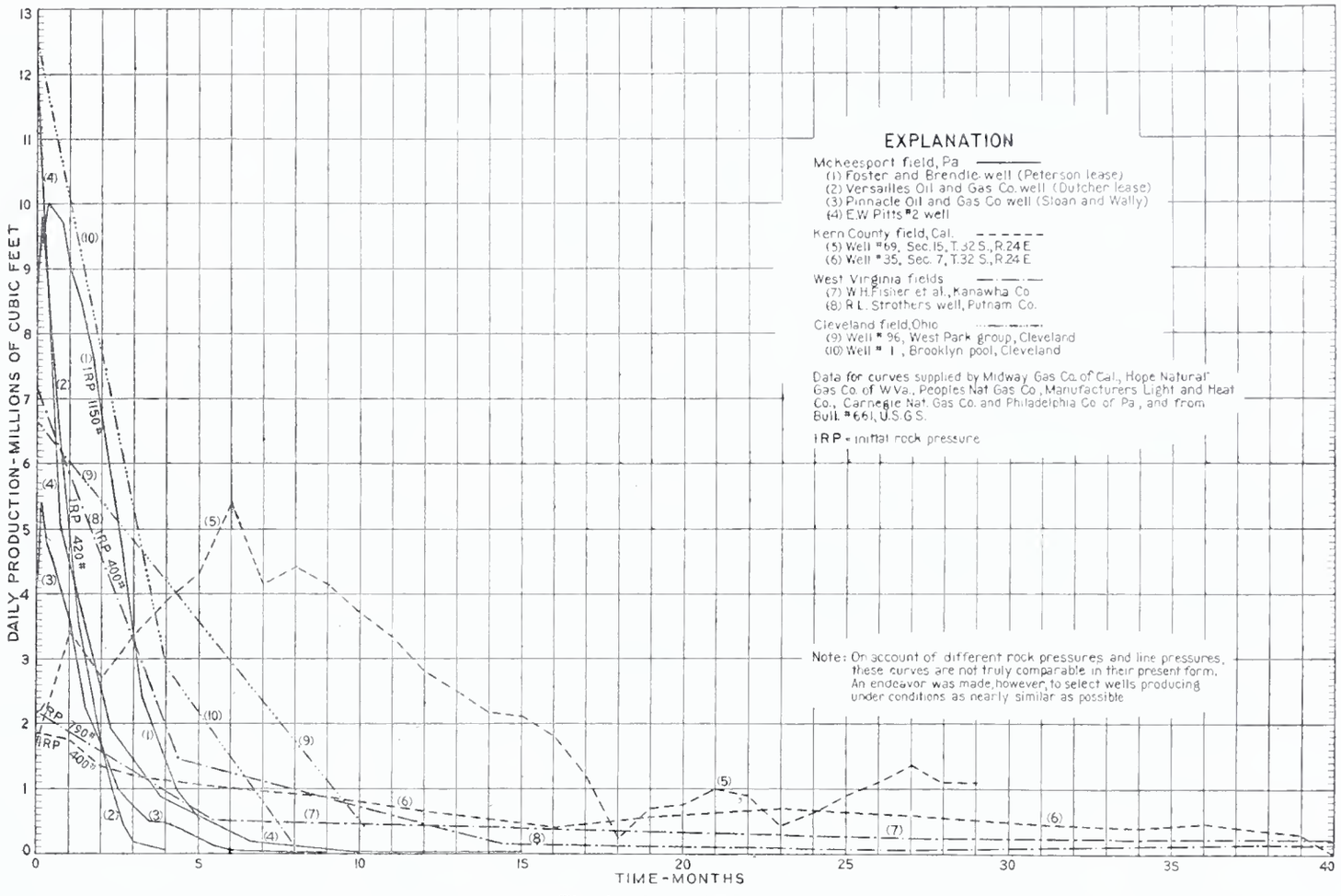


Fig. 4. Production curves of selected gas wells.

Calculation of Gas Reserves.—Rock pressure may serve as a measure of the amount of gas in a pool in just the same manner as a float tells the depth of water in a tank. If a tank is 10 feet deep, and in lowering the water level one foot 1,000 gallons are drawn off, it is obvious that there were originally 10,000 gallons of water in the tank. In rough calculations, it is assumed that Boyle's law does hold and that the volume of natural gas is inversely proportional to the pressure upon it. If a well comes in with an initial rock pressure of 600 pounds and 6 months later shows a pressure down to 300 pounds, the gas supply of the well may be assumed to be one-half exhausted, provided this is the only well in the pool or that all of the wells in the pool have been closed for 24 hours in order to restore the static pressure in all of them. (See figure 5.)

In general, given the closed-in rock pressure of any two dates and the volume of gas that has come from the well between those dates, the volume of gas remaining in the pool may be estimated by multiplying the number of cubic feet that came from the well between the two pressure measurements by the fraction:

$$\frac{\text{Last pressure reading less atmospheric pressure (14.6 lbs.)}}{\text{Difference in two pressure readings.}}$$

Limitations of Method.—This result will be correct in a pool of very limited extent only, because natural gas in a sandstone reservoir cannot flow as freely as in an open tank; therefore, the fall of pressure will not be uniform. The pressure fall measured is the fall near the well and if the sand is fine grained or the pool is large, the decline of pressure may decrease at a dis-

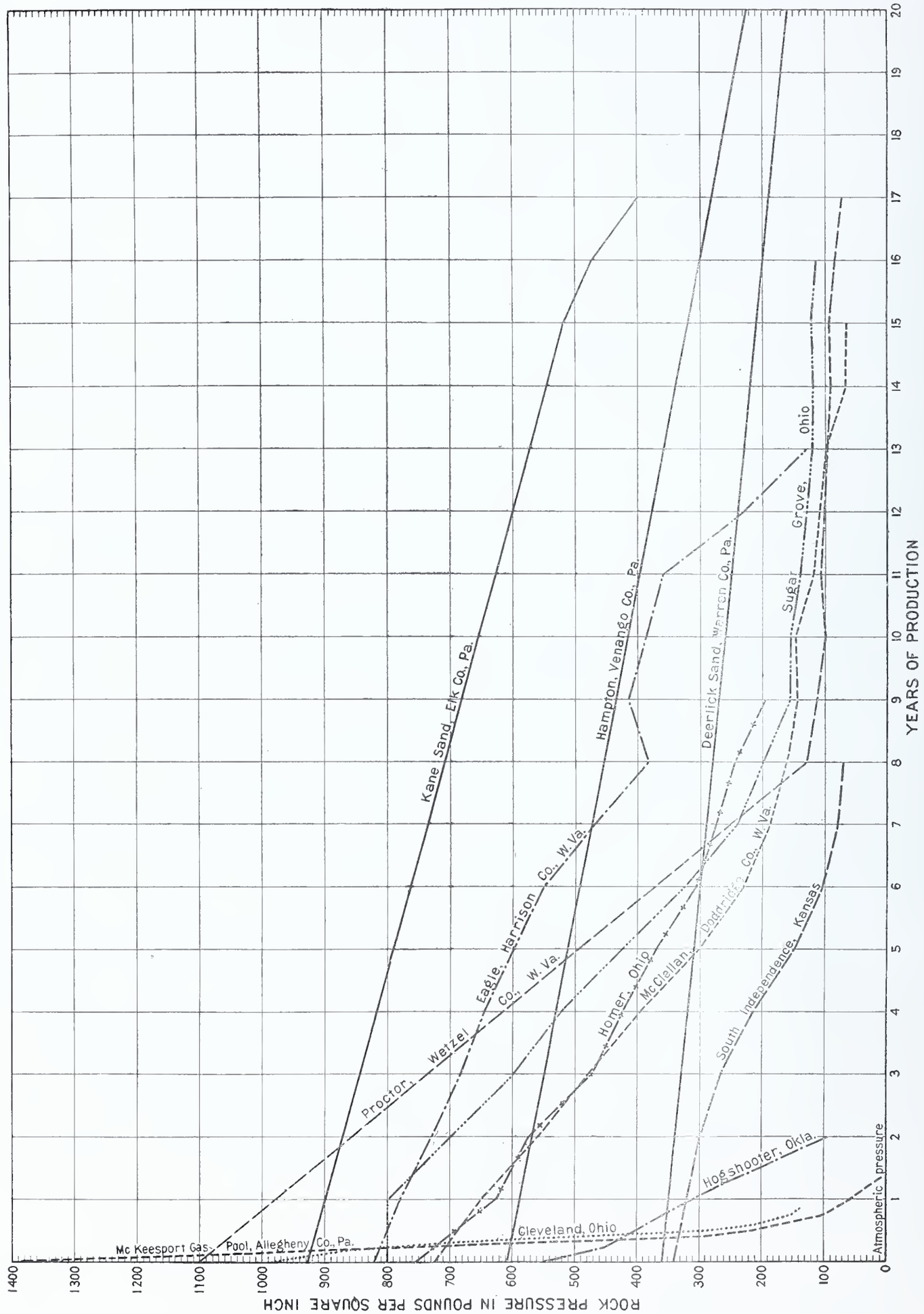


Fig. 5. Curves showing decline of rock pressure in a number of fields.

tance from the well until at any given time the decline disappears at a certain distance from the well. This distance will vary in different directions according to the character of the pore space of the rock and will steadily increase with time. The whole process can be pictured in the mind by imagining a pool of gas to correspond to a pan of dry sand and the well to a hole drilled in the bottom of the pan. As soon as this hole is opened, a cone at once forms on the surface of the sand over the hole which steadily deepens and widens until the bottom of the cone reaches the bottom of the pan. Then the sand will cease flowing unless the flow is assisted, as it is in a gas pool by means of vacuum pumps. There would be this difference between the sand in the pan and the gas in a pool. After the sand ceases to flow, its surface maintains its coned surface, but gas in a field which has been locally or only partially exhausted will in time flow into the exhausted areas so as to produce a uniform pressure over the whole pool.

SPACING OF WELLS. EFFECT ON LIFE AND PRODUCTION.

If wells are drilled too far apart some of the oil or gas may be left in the rock; if too near together the cost of obtaining the oil or gas is too high because of the cost of the superfluous wells. For every pool there is an optimum or best distance between wells. This will differ for each pool or field, depending principally on the openness of the pore space of the rock. It is not possible to give in advance a rule for any field. The distance can only be determined by trial, noting the initial flow and the initial pressure of gas wells. If a new gas well, drilled between two old gas wells, shows a rock pressure far below the initial pressure of the old wells, it is clear that the old wells had already drawn much of the gas away from the position of the new well and given time enough, would doubtless have drawn all of it away. In this instance the new well was not needed and only added to the cost of the gas. If, however, a new well shows a rock pressure nearly or quite equal to the initial rock pressure of the old wells on either side, it is just as obvious that the new well was needed. Account must be taken of the time element. If the new well were drilled only a few weeks after the old wells, the result might be very different from that obtained if the new well had been drilled a year later. There may be times when close drilling is required in order to meet an immediate demand. But, in general, drilling is most efficient that gets all of the oil or gas with the smallest number of holes. Until experiment has established the need of closer drilling, it may be taken as a general rule that gas wells should not be less than 2,000 feet apart. Oil wells, on the other hand, may be drilled locally 200 feet apart and in pools of close grained rock, may be even nearer together.

The following figures show the number of acres held for each well by some of the large gas companies:

The average for the United States is 313 acres. It may be noted that the tendency is toward a smaller acreage, due to the fact that nearly all of the acreage believed to hold gas has been taken up by the large companies and is being held as reserve. As old wells become exhausted or reduced in production, new wells in the reserve acreage have been drilled, reducing the total acreage per well.

The question has been asked: "What is the smallest number of wells that would have taken care of the McKeesport gas pool?" It is possible that had the Foster and Brendle Hamilton No. 3 well been the only well in the pool, it would have ultimately drained all of the gas in

Number of acres held per available well.

Year	1906	1910	1915	1917	1918
West Virginia, as a whole,	586	825	420	405	242
Hope Natural Gas Co.,		750	345	366	
United Fuel Gas Co.,		5600	1700	1250	
United Natural Gas Co.,		212	175	272	
Pennsylvania Gas Co.,		430	240	366	
United States Steel Corporation,			210	185	140

the pool. Almost certainly three wells would have drained the field, with one well in the Versailles district and one in the Five Fields area.

ESTIMATION OF RESERVES OF OIL AND GAS.

There are two factors involved here: First, the amount of oil or gas that may be pumped from an oil or gas well; second, the amount of oil remaining in the sand that is not removed by the ordinary methods of pumping.

OIL OR GAS OBTAINABLE BY PUMPING.

To determine the amount of oil or gas that may flow or may be pumped from a well, it is neeessary to know at first the initial flow and the initial pressure of a gas well; second, the rate of decline of flow (and the pressure at some subsequent date); third, to have curves showing the total life of other wells in the same or a similar field.

Thus, it was possible to estimate and predict the life of the McKeesport pool as soon as two sets of rock pressure measurements were available when taken with the record of flow between the initial and the subsequent measurements. Given these figures eomparison was at once made with figurcs from other pools. It was found that the figurcs agreed most closely with those of wells in the Cleveland field, from which eomplete well curves were available. How satisfactorily the method worked in this instance is today common history. It must be remembered that the production curve will differ for different sands. An open grained sand may start with a high initial flow which declines rapidly, while a close-grained sand may start with a much smaller production which declines very slowly. Under the pumps a well in an open grained sand may continue production with a flat curve for a long time, because the pull of the pumps can reach farther in such a sand than in a fine grained sand.

FEDERAL TREASURY DEPARTMENT METHOD.

The method adopted by the Federal Treasury Department[1] for estimating recoverable reserves is as follows:

"The underlying principle of the methods outlined is that **the best indication of the future production of any well is to be found in the history of similar wells in the same or similar districts**, and that, other things being equal, a well's production is more likely to approximate the production of a similar well in the tract or district than to deviate widely from the average.

"The method may be summarized as follows:

"1. Plotting the record of production of individual wells, or, lacking such detailed information, the average production per well for each tract.

"2. Deriving from these graphical records an average or composite production decline curve for the district.

"3. Estimating from last year's average production per well the probable future production, based on the average production decline eurve, or a future production curve derived from the production decline curve.

"4. Ascertaining probable total future production of producing wells by multiplying average future produetion per well by the number of wells producing at the end of the year.

"5. Estimating the probable future production of undeveloped proven land on the basis of near-by production, making due allowance for the decline in pressure due to the extraction of oil from the pool."

RESERVES OF OIL LEFT IN THE GROUND AFTER EXHAUSTION BY PUMPING.

It is generally recognized today that because of the attraction of the oil for the surfaces with which it is in contact and in part beeause of the self sealing of wells with paraffin, that much, if not most of the oil in the sands, remains in the ground after wells have ceased to flow by the usual methods of pumping. The amount of oil remaining doubtless varies with the character of the sand; in an open grained sand the amount may be relatively small; in a close grained sand it may be three-fourths or more.

Various methods have been tried or proposed for the removal of paraffin in the wells; one is the introducing of steam or of a light, refined oil

[1]Manual for the Oil and Gas Industry, U. S. Treasury Department, Washington, 1919, page 27.

which dissolves the paraffin; or again, by the introduction of hot oil which is pumped back and forth from the foot of the well, or by the use of electric heaters which heat the rock around the foot of the well so as to melt the paraffin.

To remove the oil left in the rock, at least three methods are in use. All depend on restoring the pressure back of the oil. In all, one well is selected in the middle of a group of wells, or new wells may be sunk around the selected well. The pressure is restored by: (1) Introducing into the selected well either natural gas under natural pressure, or (2) air under the pressure of pressure pumps (The Smith-Dunn Process), or (3) water which by its own weight supplies the necessary pressure.[1]

Notable examples of increased recovery of oil by the use of all three methods are found in the Bradford field of Pennsylvania. The effect of the use of air in that area is shown in Figure 6.[2]

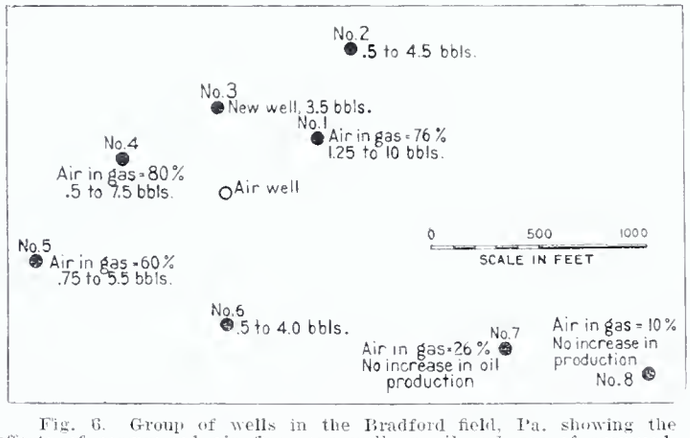


Fig. 6. Group of wells in the Bradford field, Pa. showing the effects of compressed air from one well on oil and gas of surrounding wells.

In this instance the production was increased from 3½ barrels to 31½ barrels, or 9 times. The pressure used was originally 60 pounds which was later increased to 80 pounds with a marked increase of oil and still later to 125 pounds with a further increase of oil; but this high pressure had to be discontinued as it made the gas from the wells—which was being used in a neighboring town—unfit for use.

Where the use of water has been tried in the Bradford field, single wells affected have increased from ⅛ of a barrel to ½ barrel or more, sometimes increasing the production to as much as 15 barrels a day. For example, a property which with 10 wells had been yielding between 1 and 2 barrels a day, under flood rose to 12 barrels a day.

It must be recognized that conditions in the Bradford field are extremely favorable for the use of either air or water. Probably no other field in the State has as favorable conditions and indeed it is possible, judging from tests already made, that the method of flooding cannot be successfully used in most of the other fields, if in any. Whether all of the oil is gotten out of the sands at Bradford is not known. Reports of drilling in the flooded area indicate that the process does not yield 100% recoveries.

THE OUTLOOK FOR OIL AND GAS IN PENNSYLVANIA.

GENERAL SITUATION.

One of the largest questions before the public today is, what are the sources of future supplies of oil and gas. Pennsylvania has passed from the position of the leading producer of both oil and gas to a secondary place in the production of gas and to the position of tenth among the States in the production of oil. The oil and gas wells of Pennsylvania, however, have a staying power that may keep the State in the game for many years to come and while the actual production may steadily decline, the relative position of Pennsylvania may improve through the more rapid decline of the oil and gas fields of the other States.

OUTLOOK FOR OIL.

The outlook for oil is different from that for gas so the two will be considered separately. As pointed out in the chapter on production, the large scale production of oil began in Venango County, Pennsylvania, in 1859. From the point of "discovery" at Titusville, drilling spread slowly over the adjoining counties. At first, it was confined to the stream valleys. Then it was discovered that oil could be gotten under the

[1] J. O. Lewis, Methods of Increasing the Recovery of Oil from Wells, U. S. Bureau of Mines Bulletin 148, 1917

[2] Idem, P. 115

hills though at greater depths. Gradually drilling spread to the Bradford field to the northeast and to the Butler and Clarion fields to the southward. Then oil was found in Washington County, which resulted in bringing up the State's production to about 30 million barrels a year in the early '90's. Since that time nearly every part of the State has been tested so that it appears probable that today a fairly accurate estimate may be made of the outlook if not of the actual future production.

Oil Fields Limited on East—It appears probable that the actual productive oil area of the State has already been closely outlined. As shown by the map, the oil fields of the State are limited on the east by a fairly sharp line which in a general way runs from the northeast corner of McKean County, just east of Clarion and Pittsburgh, to a point a little east of the southwest corner of the State. A few pools lie east of this line, as, for example, the Gaines and Fayette pools and several pools in the south and southeast parts of Greene County. Aside from these pools only minor showings of oil have been found east of this line notwithstanding that thousands of wells have been drilled which found a large amount of gas. While it cannot be safely asserted that no additional oil will be found east of that line, and while it is probable that additional small pools will be found, it appears probable that the part of the State east of that line may be definitely considered as out of the main oil area of the State.

Limits to Northwest.—The exact boundary of the oil field on the northwest is less definite than on the east. The lack of oil in Mercer, Crawford and Erie Counties is due primarily to the disappearance in that direction of most of the oil bearing sands. In general, all of the sands, except the Berea, and Salamanca or Third sand have thinned out under most of those counties. The Berea is thin (8 to 30 feet) and the Salamanca very thin (2 to 15 feet), where they outcrop across Erie and Crawford counties. Inasmuch as the Berea is thick in northeastern Ohio and in Venango County, it would seem probable that it is thick in places in Mercer, Crawford and southern Erie counties. It is also possible, if not probable, that if such areas of thick Berea exist, some of them contain oil. The exposures of the Salamanca sandstone or Third oil sand are everywhere impregnated with petroleum. These sandstones probably may be counted on for some oil and possibly for a considerable production. The finding of oil in these nothwestern counties will be difficult because the structure is a gentle monocline and the hard rocks are buried beneath a mantle of glacial debris. It will, therefore, be merely a matter of indiscriminate testing.

A further possible source of oil in the northwestern counties of the State exists in the deep Medina ("Clinton sand" of Ohio) sandstone which is gas bearing all along the south shore of Lake Erie and down through central Ohio but which has yielded some oil in eastern central Ohio, and is possibly the source of a little oil which has come from wells in Erie County. This sand occurs at a depth of about 2,500 feet below the surafce at Erie or at about 1,800 feet below sea level. At Pittsburgh this sand is about 7,300 feet below sea level. Its depth at any intermediate point between Erie and Pittsburgh may be taken as roughly proportional to the relative distance of that point between Erie and Pittsburgh. Thus, Meadville in Crawford County is approximately one-fourth of the distance from Erie to Pittsburgh. The Medina sand may, therefore, be assumed as 1,800 feet plus $\frac{1}{4}$ of [7,300 feet minus 1,800 feet], $\frac{1}{4}$ of which quantity equals 1,375 feet. This quantity added to 1,800 feet equals 3,175 feet below sea level. As Meadville is 1,078 feet above sea level, the Medina has a depth of (3175 plus 1078) about 4,250 feet below the surface of the ground.

Future Oil from Main Field—From Present initial daily production of 2.9 barrels. The total production for the year was made up from wells of all ages including those just drilled and those ready to be abaandoned some of which were 30 yeaars or more old. If it be assumed that all new drilling were stopped, the total future production could hardly exceed a total of a uniform decline of from about 7 million barrels the first

year, thereafter, to 0 in say 30 years, or a total of a little over 50 million barrels. The total would probably be much under that.

From New Drilling.—Second, what may be expected from new drilling? First, the percentage of dry holes has perceptibly decreased as the amount of wild catting has decreased. This is shown by the following figures:

Record of Wells Drilled in Pennsylvania for Selected Years.

Year	1890a	1895a	1900b	1905	1910b	1915	1918	1920c
New Wells	6358	6676	4451	3095	2201	1808	1827	3113
Dry	1049	1463	974	763	285	286	212	306
% dry wells	.16	.20	.21	.24	.13	.16	.11	.09

a includes northern West Virginia; b includes Allegany County, New York. c does not include McKeesport.

Second, the average initial production has shown a fairly steady decline from the early days of the McDonald field in the early '90's. The following table shows what has been happening:

Initial Production of Wells in Pennsylvania by Fields.

Year	1891	1895	1899	1905	1910	1915	1918	1920	1921
Bradford,	6.1	6.8	7.5	3.7	3.0	3.3	2.7	2.6	2.2
Middle,	8.4	7.8	4.9	2.8	2.2	2.2	2.3	1.4	1.2
Venango & Clarion,	6.9	4.3	3.0	2.5	2.0	1.4	1.9	1.5	1.3
Butler-Armstrong,	37.9	19.3	7.8	10.2	9.8	19.1	2.6	4.0	2.2
Southwest,	148.3	38.4	34.0	9.6	13.8	16.2	7.6	12.2	3.7

The figures for southwestern Pennsylvania in 1920 are 12 per cent higher than they would have been because of one large well in Greene County. While these figures show that the decline is irregular, the general fact of the decline is too obvious to be mistaken. From the figures quoted, it is evident that most of the drilling of recent years has been in proven territory and probably at points from which some of the oil had previously been withdrawn by earlier drilling. Decline curves are not yet available for showing how wells drilled in recent years compare with older wells in staying powers. It is anticipated that, as most of the recent drilling has been in the gaps left in earlier drilling, the wells will be shorter lived. The combination of reduced initial flow and possible shorter life will, in time, act together to bring the total flow of the average well to a point where it will not pay the cost of drilling and maintenance. An increase in the price of crude petroleum will postpone the coming of such a time, assuming that the cost of drilling does not increase correspondingly. In some of the fields it would appear that the point of vanishing profits would be reached in about 10 or 15 years unless new sands are found or some means devised for renewing the wells.

For over 10 years production of oil has been maintained at between seven and eight million barrels or a little over. A comparison of the total number of new wells with the total production for the years 1900 to 1920, inclusive, gives definite evidence of a decline.

New Wells and Production in Pennsylvania, 1900-1920, Inclusive.

Year	New initial production	No. of new wells	Average initial production	Total production	Average price
1900	32,528[1] bbls.	3477[1]	9.3 bbls.	13,741,801 bbls.	$ 1.35
1902	19,656[1] "	2875[1]	6.9 "	12,414,857 "	1.23
1904	13,835 "	2614	5.2 "	11,125,762 "	1.62
1906	14,875 "	3104	4.7 "	10,256,858 "	1.59
1908	9,098 "	2096	3.6 "	9,424,335 "	1.75
1910	6,315 "	1918	3.2 "	8,794,662 "	1.33
1912	6,195 "	2226	2.9 "	7,837,948 "	1.64
1914	6,627 "	2032	3.2 "	8,170,335 "	1.88
1916	10,774 "	2298	4.6 "	7,592,394 "	2.51
1918	4,621 "	1423	3.2 "	7,407,812 "	3.35
1920	8,641 "	2600	3.3 "	7,454,400 "	6.10
1920[2]	7,241 "	2599	2.8 "		
1921[3]	409 "	184	2.22 "		

1—includes New York and West Virginia. 2—without Mecks well. 3—January only.

A study of this table in connection with the production curves of Figure 8, brings out the following facts regarding the production of oil in Pennsylvania: first, a fairly steady rise of production to 1874 with a slight decline to 1876; second, the opening of the Bradford field in which production increased rapidly to a maximum of 25,000,000 barrels with a corresponding decline in the other fields of the State; third, in 1885 and 1886 the production from Washington and Greene Counties became prominent, increasing the total production of the State by 5,500,000 barrels in 1886. This was followed by the usual decline. Fourth, in 1890 and 1891 the McDonald field came in with a number of very large wells that with a general growth in the southwestern district doubled the output of the State between 1881 and 1891. Fifth, from 1891 there has been a nearly steady decline, very rapid at first (from 1891 to 1912), since when the production

has been irregular but indicating definitely a continuing decline. If the rate of decline from 1914 to 1920 continued uniformly, the production of Pennsylvania would reach its end about 1980 with a total additional production of about 220,000,000 barrels of oil.

The decline will be affected by three factors. First, the rate of decline becomes less each year, which may prolong the production of oil for many years. Second, the point of vanishing profits will be reached long before the normal production reaches zero, as previously explained. Third, there is the latent possibility of finding new pools or of reviving old pools. This brings us to the third angle of the problem, the possibility of finding new pools.

From New Oil Pools.—As already pointed out, the thousands of wells drilled east of the main oil field that, while finding gas, have failed to find oil, seem to indicate the absence of any large pools of oil in that direction. That additional small pools will be found is to be anticipated. The chance of finding small pools northwest of the main field is much better and there is a possibility that other pools as large as the Volant will be revealed, with the bare possibility that deep drilling may open up a large reservoir of oil in the Medina sand in central-western Pennsylvania.

Within the main field, however, the outlook is for a continuation of the present method of testing the gaps left in earlier drilling with the prospects of an occasional good well (that is, 100 to 1,000 barrels initial daily production) but with a general tendency to a steady decline in initial production to a minimum where the return of the average well does not pay the drilling, interest and amortization costs. Large parts of the main oil fields have had a drill hole sunk in every square mile and hold out no hope of new pools. Other parts have been tested less thoroughly and may prove to contain many new pools, some of which may be of real importance though there does not seem to be any possibility of the finding of any large pools, such as the Bradford or McDonald, which would produce a large upward jump in the State's production.

The question is often asked, are there not lower sands as yet untouched in the oil fields that may renew or increase their life? Continued study of the problem seems to lead to two conclusions, first, that during recent years many scattered holes have been drilled to depths of from 4000 to 7000 feet or more which seemed to have tested the sands to that depth in nearly all parts of the field and, second, that these holes have, as a rule, found in the deeper sands only gas or nothing.

It, therefore, appears that while much new oil is certain to be found, including many new pools, the prospects are not bright for the finding of any new large deposits of oil in the State.

There remains one important phase of the problem. It is recognized that from a hard, small-pored sandstone such as certain of the oil sands of Pennsylvania are believed to be, the initial production of wells is, on the average, small and that the long drawn out decline is due in part to the sealing of wells in the sand by paraffin and in part to the reduction in pressure needed to force the oil into a well. Will it be possible to revive pools or fields near exhaustion by the removal of the paraffin or the introduction of new pressure? How much additional oil may be counted on being obtained from these revived wells?

From Rejuvenation of Old Fields.—The removal of the paraffin, as mentioned in the preceding paragraph, is claimed to have increased the flow of oil from a given property by 300 per cent. As the methods and results of the rejuvenation of the Bradford field have been published recently in Bulletin 148, issued by the U. S. Bureau of Mines, it is not necessary here to go into details. The rejuvenation of the Bradford field has not been in operation long enough to show exactly what the final returns per acre will be. From such data as are on hand, Mr. Lewis, the author of Bulletin 148, estimates that the use of the Smith-Dunn (compressed air) or other processes may not be counted upon to increase the production of the average pool in the Appalachian field more than 50 per cent and that

such an increase will be possible only when the operation is maintained as long as it can be made to pay. If it be assumed that the total production of oil in Pennsylvania to 1921 has been over 750,000,000 barrels and that the future production without the use of special methods of recovery will bring the total to 900,000,000 barrels, it may be estimated that the use of special methods of recovery may increase this by one half or to 1,350,000,000 barrels. That estimate postulates a total future recovery of 600,000,000 barrels.

At present this may appear like a purely theoretic recovery but it is based on the results of actual experience. It may be more conservative to assume a total recovery of 1,000,000,000 barrels of which nearly 250,000,000 barrels, or one fourth, are still to be gotten. But the possibility of a much greater recovery should not be lost sight of, particularly in view of the prospect of ever increasing prices for crude petroleum and of the certainty that future inventions will revolutionize our methods of recovery.

It may, therefore, be anticipated that notwithstanding new drilling the production of oil in Pennsylvania is destined to decline slowly and steadily to a vanishing point which may not be reached for 100 years but which may be approached within 20 or 30 years.

THE OUTLOOK FOR GAS.

The outlook for gas differs materially from that for oil; especially in three respects. First, exhausted gas pools are exhausted for all time. Second, the gas fields cover a much wider territory much of which has not been fully tested and part of which has hardly been tested at all. Third, the deeper sands, that hold out little promise of oil may hold in reserve large volumes of gas.

Exhausted Gas Pools.—A body of gas in a porous sandstone differs from a similar body of oil in that it appears to flow more readily so that under the action of high vacuum pumps it would seem that all of the gas in a pool is drawn out. This does not mean that there may not be detached pools in the midst of or adjoining the main pool which are shut off from the main pool by non-porous sand. The McKeesport gas pool was entirely cut off from adjoining pools on the north.

The future supply of gas in Pennsylvania must, therefore, depend on: first, the life of the present gas wells; second, the drilling of new wells in the fields not yet exhausted; third the finding of new pools or new fields.

Life of Present Wells.—A gas well has a life much like that of an oil well though with some slight differences. Because of the readier flow of gas through the rock, it is sometimes true that a gas well will continue to yield the same flow for a long time or may even increase its flow for a time as the current of gas under its high pressure may dislodge the grains of sand in the sandstone and open up channels to the well. Thus, some of the earlier wells at McKeesport blew sand into the pipe for months after they were opened.

Again, it is possible, by the use of high vacuum pumps, to continue the life of a gas well for a very long period after the pressure has been reduced to atmospheric pressure. This feature also is well illustrated by the McKeesport pool. It is a surprise to most persons, after the rapid decline of the McKeesport pool in the spring of 1920, to learn that the pool entered 1921 making about 9,000,000 cubic feet of gas a day with the prospect of running many months into the year. It must be remembered, however, that this production has been maintained only by steadily lowering the pressure with the pumps or, as it is more commonly expressed, increasing the vacuum.

In the past, gas wells like oil wells have differed in length of life from a few months to 30 years or more. Wells recently drilled in new fields are as likely to have long life as wells drilled 30 years ago—provided, that drilling today or in the future is not more closely spaced than in the past. That means that some wells drilling today will be flowing 30 years from now. In general, however, it may be anticipated that new fields will be more and more closely drilled with the result of reducing the life of the wells now flowing.

If no more wells were drilled, it might be closely estimated that the production of natural gas in Pennsylvania will decline rapidly at first then more and more slowly to extinction in 30 or 40 years. In 1918 the gas production of the State was nearly 124,000,000,000 cubic feet. If not replenished by new drilling it is probable that 5 years would see that amount reduced one half, ten years to one quarter and so on, yielding a total future production of less than 1,000,000,000,000 cubic feet.

Prospects for New Drilling.—New drilling may be of two kinds. First, the drilling of additional holes in developed pools which will hasten the exhaustion of the pools but which will not add materially to the total volume of gas recovered. These new wells may start with a large flow, but as a rule the rock pressure will be low and the volume of gas will decrease rapidly. The effect of new drilling in developed pools was illustrated in a striking way in 1920 by the drilling of some large wells in Allegheny County. Two wells were drilled in Nine Mile Hollow in May, 1920. May 6th one well was yielding an open flow of 1,250,000 cubic feet per day. June 17th this well was producing only 150,000 cubic feet. May 20th another well in this area had a flow of 3,000,000 cubic feet a day but was soon drowned out. The same story was being told at that time in a multitude of other gas wells which came in "big" during that winter.

The second type of new gas wells are those in new pools, either in pools in the lower sands previosly undrilled or in areas not previously drilled. The discovery of the McKeesport pool in a lower sand, the Speechley, in an area dotted with gas wells some of which were 30 years old or more, illustrates the possibility along this line. That other pools will be discovered in lower sands is to be anticipated, though it is unlikely that other pools as rich as that at McKeesport will be found. During the last few years many holes have been drilled to 4,000 feet or more for the express purpose of testing the Speechley, Bradford and other lower sands. This drilling has, as a rule, shown that the lower sands are less persistent and less reliable than the upper sands and while disclosing much additional gas, does not hold out hope that these lower sands will materially retard the anticipated general decline.

Possible exception to this general condition may exist in the very deep Oriskany and Medina sandstones. The Oriskany sand yields gas where pierced in the Ligonier well at 6822 feet (8450 feet, estimated, below the Pittsburgh coal), but did not yield gas where pierced in the McDonald well (6100 feet below the Pittsburg coal) nor has it been reported as present or gas yielding in the wells drilled through its horizon in the northwest corner of the State. This sand, it may be roughly estimated, lies about 7150 feet below the Pittsburgh coal along the Murrysville anticline and 7600 feet below the Pittsburg coal under the Fayette anticline in Fayette County and southern Westmoreland and under the Grapeville anticline in nothern Westmoreland County. Substracting from these intervals the estimated height of the horizon of the Pittsburgh coal from the surface of the ground to any point along these anticlines would give the depth to the sandstone. Thus, wells in Snake Hollow in the McKeesport pool were estimated to start about 500 feet below the position of the Pittsburgh coal. A well at that point should, therefore, reach the Oriskany sand at about 6650 feet. Jacobs Creek in Westmoreland has an elevation of 940 feet where crossed by the Fayette anticline. The Pittsburgh coal, had it not been removed, would have had an elevation of 1800 feet or 860 feet above the surface of Jacobs Creek, at that point. Subtracting 860 feet from 7600 feet leaves 6740 feet as the estimated depth at that point to the Oriskany sand.

The Medina sand is supposed to underlie at least all of northwestern Pennsylvania and possibly all of southwestern Pennsylvania as well. This sand has been reached by drilling in Erie County where it has proved gas yielding. It has been reached by a large amount of drilling in northern and central Ohio and has been the source of very much of the natural gas obtained in that State. Its depth in the McDonald well has been estimated at 8300 feet below the Pittsburgh coal and in the Ligonier well at 10,150

feet. Its depth under the intermediate anticlines would be between those two figures. Thus in the McKeesport area its depth may be estimated as about 9100 feet below the Pittsburg coal or 8600 feet below the bottom lands of the Youghiogheny River. Along the Fayette anticline on Jacobs Creek, the Medina sand may be estimated as 9600 feet below the Pittsburgh coal, or 8840 feet below the level of Jacobs Creek. Just what possibility there may be of this sand containing gas must be purely a matter of surmise until it has been tested with the drill.

There still remains the possibility of new gas fields or the extension of present fields to adjoining areas as yet untested. The map shows that gas, in the main, is confined to a belt from 30 to 60 miles wide lying either side of a line from the northeast corner of McKean County through Pittsburgh to the southwestern corner of the State. Within much of this belt the gas pools are so closely spaced as to suggest that nearly or quite all of the territory has been tested, though doubtless there are many small areas yet untested that will yield pools of gas, some of which may be of some magnitude. In the northern part of this belt there are large areas, especially in Forest and Elk Counties, that are not now yielding either oil or gas. The Survey is not as yet in possession of information that would serve to explain why those areas have yielded neither oil nor gas. Until a study of this area has been made, it may be assumed that all of Forest County is possible oil territory and that all of Forest and at least the norwestern half of Elk County is possible gas territory. Within this area, however, testing for gas had best be confined to the anticlines. The structure of Forest County has not been worked out and judging by experience in areas restudied, the position of the anticlines in Elk County as determined by the Second Survey should not be accepted without confirmation. The anticlines shown on the Second Survey maps were, as a rule, determined at only a few points and those points then connected with a ruled line. Detailed mapping has shown that practically none of the axes are straight lines so that in places the actual position of the anticline may be several miles from where previously shown. It is also true that in places mistakes were made in connecting axes together.

With this suggested caution, which should lead to careful field determination of the exact position of any anticline before drilling is started, attention is called to the fact that both sides of the anticlines in Forest, Elk, and Jefferson Counties are, geologically, areas favorable to the occurrence of gas. In general, the western side of the anticline may be considered the more favorable area.

Prospecting in the Eastern Part of the Coal Field.—East of a line from the southeast corner of McKean County to the southeast corner of Greene County, is a large area in which are dotted a few small gas pools and which may, therefore, be considered possible gas producing territory. Fifteen years ago, the present State Geologist was very hopeful that proper drilling would reveal large bodies of gas under the anticlines throughout this large area. At that time, a small gas pool existed on the western flank of the Chestnut Ridge anticline, and a still smaller pool on the Laurel Ridge anticline was producing gas; but in the main, the test wells drilled up to that time had been in the synclines and, therefore, could not be considered as of value in showing the presence or absence of gas. Since that time, however, the structure of most of this territory from the center of Clearfield County southward has been mapped in detail and published and a number of test holes have been sunk on the crests of the anticlines as revealed by these studies. To date this drilling has yielded no productive wells and while not conclusive is certainly discouraging. Most of the gas found in this mountain area has come from one or the other of two sands, one of which lies about 700 feet below the Brookville coal at the base of the Allegheny formation and the other 1550 feet deeper. The upper horizon has been called the gas sand and may be equivalent to the Berea or First sand, while the lower gas horizon has generally been classified as the Speechley. These intervals hold for the Chestnut Ridge anticline. Further east, the intervals should be larger.

At present the outlook in this large area is as follows: the Uniontown-Connellsville-Latrobe syncline may be taken as the dividing line between the productive area on the west and the non-productive area on the east. East of that line a multitude of small gas pools probably exists, but judging from past experience finding them is likely to involve the drilling of a large proportion of dry holes. Indeed, until natural gas sells at a much higher figure than at present, the cost of prospect drilling in this area is almost certain to exceed the value of the gas obtained (all wells considered) and so will discourage prospecting.

When the price paid for gas and the cost of drilling reach such figures as to hold out hope of adequate returns, drilling should be started on the crests of the domes shown on the structure map or of domes to be shown in reports published in the future.

A factor of possible large importance in determining the position of gas in this area is the extent to which the rocks have been affected by folding as shown by the fuel ratio of the coal. It has been pointed out that the productive oil fields of Pennsylvania, as elsewhere, are confined to areas in which the coals, if present, have a fuel ratio (fixed carbon divided by volatile matter) of less than two. It is possible that in like manner commercial supplies of gas will be found only in areas in which the fuel ratio of the coal, where present, is less than a given figure. Just what that figure may be has not as yet been determined. In the following map is shown roughly the areas in which the fuel ratios of the coals are, on the average, the same.

In general, it may be anticipated that the chances of getting gas decrease as the fuel ratio increases. Thus, if a study should some day demonstrate that few or no gas pools of value occur where the fuel ratio is over 3.5, it would appear from the map that the south part of Cambria County and the northeastern part of Somerset County are outside the gas field. It seems probable that the limit is higher than the figure suggested and that gas may be found at points scattered all through the areas west of the Allegheny Front.

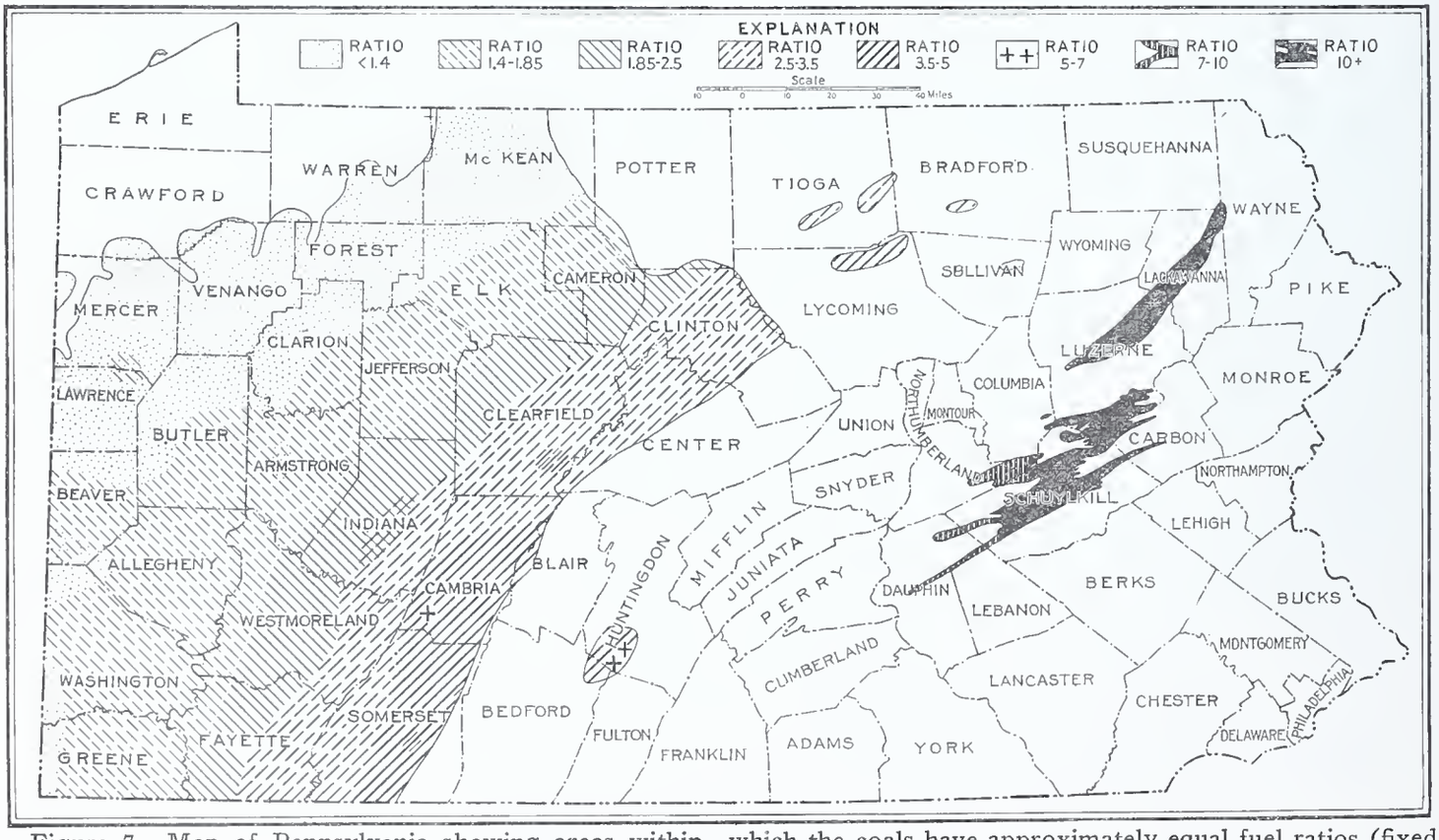


Figure 7.—Map of Pennsylvania showing areas within which the coals have approximately equal fuel ratios (fixed carbon divided by volatile matter).

Outlook in Northeast Counties of the State Including Tioga, Bradford, Susquehanna, Wayne, Lycoming, Sullivan, Wyoming, and Pike.—The surface rocks of these counties are, in the main, the red Catskill shales and sandstones that, in western Pennsylvania, include from the Second to the Fifth or Sixth sands. Beneath these lie the Chemung rocks, the formation that in western Pennsylvania includes the sands from the Elizabeth to the Gartland. Scattered drilling in most of those counties has shown the presence of small amounts of gas and leads to the belief that gas in small amount may be expected in most of that section of the State. As soon as topographic mapping has covered those counties, it is hoped to make a detailed study of the wells that have found gas to determine if they are on favorable structure or not. If it shall prove that they are, little hope could be held out for larger wells than those already found; but if it shall be found that favorable structures have not yet been drilled, it is possible that much larger gas flows may be obtained.

Among wells in this area that have yielded gas may be mentioned a well drilled near Ramsey, Lycoming County in 1904. Several gas wells have been drilled or are drilling west of Tunkhannock, Wyoming County. One of these is said to have produced a flow of gas that could be heard for some distance. Another one was drilled in 1881-1882 to a depth of 2089 feet. Gas is said to have been obtained in practically all of the wells drilled along Mehoopany Creek, Sharps Pond, and Cassam Brook. Most of these wells were from 1200 to 1400 feet deep with presure of about 860 pounds.

Some gas has been found in Susquehanna County, as on the Wheaton farm north of Montrose, and on the Cahill farm in Middletown township. A well drilled at Narrowsburg, on the New York side of the Delaware River to a depth of 800 feet is said to have found some gas.

These gas wells suggest the presence of gas throughout this area covering several counties. But considering the present cost of drilling for gas and of piping the gas when found, in contrast with the small flows so far encountered, this area does not seem to offer great inducement for prospecting or hope of financial reward.

Outlook in Central and Southeastern Pennsylvania.—This large area lying east and south of the Allegheny Front is believed not to contain commercial quantities of oil or gas. Many wells have been drilled within this area in the State and in corresponding rocks to the northeastward and southwestward in New Jersey, Maryland, Virginia, North Carolina, etc., and so far with entirely negative results. At many places within this area there are "showings" of oil or gas springs and in a few places many gallons of oil are reported to have been obtained. Yet taking all of the facts into account, this Survey can hold out no hope of financial success for those seeking oil or gas here.

Central and southeastern Pennsylvania may be divided into four belts; (1) The ridge and valley area. Within this area the rocks are highly folded, commonly rising out of the ground at angles of from 30° to 90°. The rocks themselves have been slightly metamorphosed so that some of the sandstones have been changed to quartzites. The coal beds within this area have been turned to anthracite and the black shales, so far as tested, will yield no oil on distillation. Some drilling has been done in this area, and a few wells have given enough gas to light at the mouth of the well, but nothing big enough to be of commercial value has been found. (2) Southeast of this belt is the broad valley belt including, at the north and west, the Lebanon and Cumberland Valleys. Here the rocks are not only tightly folded but more or less crushed and faulted. Metamorphism has gone farther so that some of the shales have been converted into slates and some of the limestones into marbles. Many oil seepages or oil springs have been reported from this area. Analyses of the oil from some of these springs indicate a white oil very high in kerosene. The presence of these springs has led to some drilling but so far without success. (3) Within the confines of the valley belt is a narrower belt of Triassic red beds, sandstones and shales. These have not been folded, crushed or metamorphosed so fully as the en-

closing older rocks. They have, therefore, been the subject of much interest and considerable drilling has been carried on in them though as yet without success. The reason for failure here would appear to be the lack of an initial supply of plant or animal remains in the rocks to serve as a source for the oil or gas. A study of the red beds shows almost no bituminous or carbonaceous matter. Here and there are traces of coal which in Virginia and North Carolina become of commercial importance. But, in general, the material of these beds does not appear to have been laid down under conditions favorable for the existence or preservation of life. (4) The fourth belt consists of the granites, gneisses and other highly metamorphosed and igneous rocks of the southeast corner of the State extending westward into York and Adams Counties. In this belt the rocks have been so squeezed, crushed and melted that their original character is a matter of conjecture. That pockets of oil or gas may have been sealed up in these rocks is not impossible though very improbable, but that any large supply of oil or gas may yet be found in these rocks is contrary to all experience and contrary to all theories of the origin and occurrence of oil and gas. Theories, after all, are built on experience, the results of which they seek to explain. It is true that this area has not been fully tested. But many holes have been drilled here and there, no one of which, so far as learned, has ever paid for itself. More than that, drilling the world over in similarly metamorphosed rocks has yielded similar results. While therefore, this Survey is glad to see any favorable conditions tested out, it cannot recommend any drilling in this part of the State.

Summary of Outlook for Gas.—The facts given may be summarized as follows:

1. The production of gas in Pennsylvania reached a maximum of 138,000,000,000 cubic feet in 1906, since when it has fluctuated downward, reaching 123,000,000,000 cubic feet in 1918, the last year for which final figures are available.

2. The average initial daily production of new wells and the initial rock pressure has shown an even more marked decline. The following figures were published by the Peoples Gas Company, one of the largest in the State:

Decline in initial flow and rock pressure of gas wells (Peoples Gas Co.)

	1915	1916	1917	1918	1919
Average initial daily production	1,071,073	643,559	462,809	395,879	283,651
No. of wells drilled	59	118	165	137	130
Average rock pressure in lbs. per sq. in.	423	365	249	261	271

3. Such figures and a multitude of others show clearly that the present productive gas fields of Pennsylvania are slowly but certainly playing out. The decline is likely to be fairly rapid for a time, and then slower and slower until the cost of maintenance of the wells exceeds the value of the gas, which point may be 100 years or more hence.

4. Outside of the present developed fields are considerable areas that, judging only by the surface geological features, should be gas bearing. These areas may be counted on to retard the decline of gas production but are not likely to stop the decline or reverse it.

5. Far below the sands commonly developed today are two sands known to be locally productive in this State. These sands, the Oriskany and Medina sandstones, may yield large volumes of gas in the future; but their exploitation will be very expensive because of their great depth.

6. The prospects for gas decrease in going eastward form the center of the gas field toward the Allegheny Front.

7. The counties in the northeastern part of the State are underlain with rocks that are gas bearing on a small scale but do not yet give promise of large commercial production.

8. No commercial supplies of gas may be expected to be found east or south of the Allegheny Front in the central or southeastern parts of the State.

CHRONOLOGICAL DATA ON OIL AND GAS DEVELOPMENT.

B. C. 2200 From the following references it would appear that the knowledge of petroleum dates to early Biblical times:

Old Testament references: Mortar used in the construction of the

Tower of Babel was probably part petroleum. Pitch with which Noah coated the Ark, was perhaps a petroleum product.

B. C. 500 Herodotus speaks of oil springs in the Island Zante.

A. D. Oil from the Isle of Sicily was burned in lamps about the beginning of the Christian era.

A. D. 1627 Daillon, a French missionary, reports oil near Cuba, in what is now a part of the State of New York. It was called "antonontous" by the Indians.

1642 Charlevoix reports oil as a "stagnant water which would burn."

1753 Oil springs reported on Oil Creek, Pa., an account and map of which was published by Peter Kaln.

1760 Oil obtained from the distillation of coal.

1783 Gen. Benjamin Lincoln reported to Rev. Joseph Williard of Cambridge University that several gallons of Barbadoes tar could be collected by one man daily from springs near the head of Oil Creek, Pa.

1789 Oil was used increasingly for medical purposes, being mentioned in German literature.

1807 Oil for medical purposes selling along Oil Creek for one to two dollars a gallon.

1808 Oil obtained from salt wells in West Virginia along the Kanawha River.

1821 Natural gas used for lighting and heating at Fredonia, N. Y.

1828 Oil used as a lubricant.

1829 A flowing oil well was struck while digging for salt in Cumberland Co., Kentucky.

1833 Seneca oil, from Seneca Lake, Allegany Co., New York was put on the market as an antidote for rheumatism, burns, sprains, etc.

A. D. 1840 Oil from salt wells near Tarentum, Allegheny Co., Pa., reported to be a nuisance.

1846 Abraham Gasner is reported to have distilled oil from coal in the United States.

1849 Mr. Kerr sold petroleum in one-half pint bottles for 50¢ each for medical purposes.

1854 First deed conveying oil rights in Pennsylvania was made.

1855 Rock Oil Company was organized under the laws of the State of New York. First oil company in Pennsylvania.

1859 About fifty companies engaged in the distillation of oil from coal or shales in the United States. Selling prices 60¢ to 70¢ per gallon.

1859 Drakes' well, drilled in August 28th to a depth of 69½ feet. Well pumped about 25 bbls of oil daily. Price of oil was $20.00 a barrel.

1861 First flowing well obtained on Oil Creek, Pa. Many gushers flowed 3000 to 4000 bbls a day. Price of oil 10¢ a barrel.

1865 Developments extending as far as Greene County, Pa.

1868 Developments in Butler, Armstrong and Clarion counties.

1868 Small quantities of oil obtained in what is now the Bradford pool.

1872 Gas piped 5½ miles to Titusville.

1874 Natural gas first used in iron making.

1875 The famous Bradford pool under development.

1876 Much activity in the Bradford field. Warren field discovered.

1878 Haymaker Well No. 1 struck at Murrysville, Westmoreland County.

1881 Bradford pool at its maximum (21½ million bbls.)

1883 Gas piped from Murrysville to Pittsburgh.

A. D. 1884 Phillips well drilled in on Thorn Creek flowed 10,000 to 12,000 bbls of oil a day.

1885 First oil well in Washington County. Gantz well at Washington struck oil. Gas lines laid from Washington County to Pittsburgh.

1886 Developments in Washington and Greene counties.

1891 Famous McDonald field opened up. (One well produced 730 bbls an hour.)

1892 Development at Herman Station in Butler County.

1894 Finleyville pool in Washington County and North Washington pool in Butler County discovered.

1895 Considerable attention paid to the Kaylor pool in Armstrong County.

1896 Bristoria field in Greene County discovered.

1897 Attention directed toward the Fonner pool in Greene County.

1900 Brush Creek and Duff City pools in Allegheny County opened up. Large gas well struck on the Cutler farm in Washington County.

1901 Speechley sand oil pool discovered on the John Campbell farm in Butler County.

1904 First time that the production of petroleum west of the Mississippi exceeded that east of the Mississippi.

1905 A 1000 bbl oil well was completed on the Waldron farm, Butler County.

1908 High grade oil did not change a single point throughout the year ($1.79).

1911 A 900 bbl well was completed in Greene County. The Gantz well drilled in 1885 was abandoned. In Canonsburg, Washington County, a town lot proposition was being featured.

1913. Near Duff City, Allegheny County a 250 bbl well was drilled in. Several 30 to 40 bbl wells were completed in Allegheny, Greene and Westmoreland counties.

1915 The Evans City oil pool, in Butler County, come in with a boom. It was a town lot proposition and one well produced over 1500 bbls of oil a day.

1917 The deepest well in the United States and second deepest in the world was completed at McDonald, Washington County, Pa., by the Peoples Natural Gas Company. Depth 7248 feet. As a producer, the well was a failure, but it was an exceedingly valuable test. The Czuchon well in Germany holds the world's record for depth—7349 feet.

1918 A new record for deep wells was established when a well was completed on the M. O. Goff farm, in Harrison County, West Virginia, by the Hope Natural Gas Company. Depth 7386 feet. (Non-productive.)

1919 The world's record for deep drilling was again broken when the I. H. Lake well in Marion County, West Virginia, was drilled by the Hope Natural Gas Company to a depth of 7579 feet. (Non productive.) Late in this year the McKeesport gas pool was discovered. This was a town lot proposition.

A. D. 1920 Two wells in this State reached a depth of 6822 feet or more. The Ligonier well drilled by the Peoples Natural Gas Company in Westmoreland County, the other drilled by the T. W. Phillips Oil and Gas Company in Indiana County to a depth of 7002 feet. The Ligonier well is the deepest producing well in the world.

A. D. Several large oil wells were brought in in Greene and Washington counties, one of which made 1400 barrels of oil a day.

1921 Several 250 bbl wells are being completed in Greene County.

OIL AND GAS PRODUCTION.

PETROLEUM PRODUCTION.

Before the completion of the Drake well in Venango County, Pennsylvania (August 28, 1859), petroleum had been commercialized in Roumania (1857). Prior to 1860, the world's supply of oil was only a few thousand barrels a year. Figure 8, on the following page, is a graph showing the production of petroleum in the world, in the United States, in California, in Oklahoma, and in Pennsylvania for each year from date production started till the present time (1920).

The Pennsylvania production is again plotted on a larger scale together with the production from the Bradford field* (McKean County, Pennsylvania), also the production from the famous McDonald field (Washington and Allegheny Counties.)

It is interesting to note that until 1875, Pennsylvania produced practically all of the petroleum in the United States and 88 per cent of that produced in the world.

During the year 1881, Pennsylvania produced 26.8 million barrels of oil; while the total production in the United States was 27.7 million barrels, the world's production amounting to almost 32 million barrels.

Look at the large scale production curves (1881) on the following page and one will observe that the Bradford field produced about 86 per cent of Pennsylvania's production. During the year 1881, California produced about 100,000 barrels of oil.

Pennsylvania reached its maximum yearly production of petroleum in 1891, namely, 31.4 million barrels. This was 58 per cent of the production of the United States, and 34.6 per cent of the world's production for that year.

Oklahoma began producing oil in 1890.

*Estimated 1900 to 1920.

The peak of production (1891) was caused by the coming in of new fields in the southwestern part of the State. From 1891 to 1900 the petroleum production in this State declined very rapidly with a small "come back" about 1896. From 1900 to the present time (1920) the production has been declining more or less uniformly from 13.3 million barrels a year to 7.5 million barrels a year.

It is interesting to note the struggle between California and Oklahoma for first place in this big industry (oil), which place Pennsylvania was forced to yield up to Ohio in 1895. Pennsylvania is now in tenth place in the United States production scale.

During 1920, Pennsylvania produced only 7.1 per cent as much petroleum as California, 6.9 per cent as much as Oklahoma, 1.7 per cent of the production of the United States, and 1.1 per cent of the production of the world.

NATURAL GAS PRODUCTION.

Pennsylvania's maximum yearly production of natural gas was in 1906, the production amounting to 138,161,385,000 cubic feet. The consumption was 162,095,173,000. From 1906 to the present time the production has been declining more or less regularly with a small "come back" from 1915 on. The consumption, however, has been increasing, and reached its maximum in 1917; namely, 202,259,498,000 cubic feet.

The following table gives the natural gas production 1906-1918 in Pennsylvania and the United States, as well as the consumption in Pennsylvania.

	Production—in M cubic feet.		Consumption—in M cubic feet.
	Pennsylvania	United States	Pennsylvania
1906	138,161,385	388,842,562	162,095,173
1907	135,516,015	404,441,254	164,541,170
1908	130,476,237	462,140,730	147,790,097
1909	127,697,104	480,706,174	163,656,145
1910	126,866,729	509,155,369	168,875,559
1911	108,869,296	508,364,021	154,475,376
1912	112,147,855	562,203,452	173,656,003
1913	118,860,269	581,898,239	177,463,230
1914	110,745,374	591,866,733	164,834,542
1915	113,691,690	628,578,842	176,367,235
1916	130,483,795	753,170,253	201,460,893
1917	133,397,206	795,110,376	202,259,498
1918	123,813,356	721,000,959	177,139,804

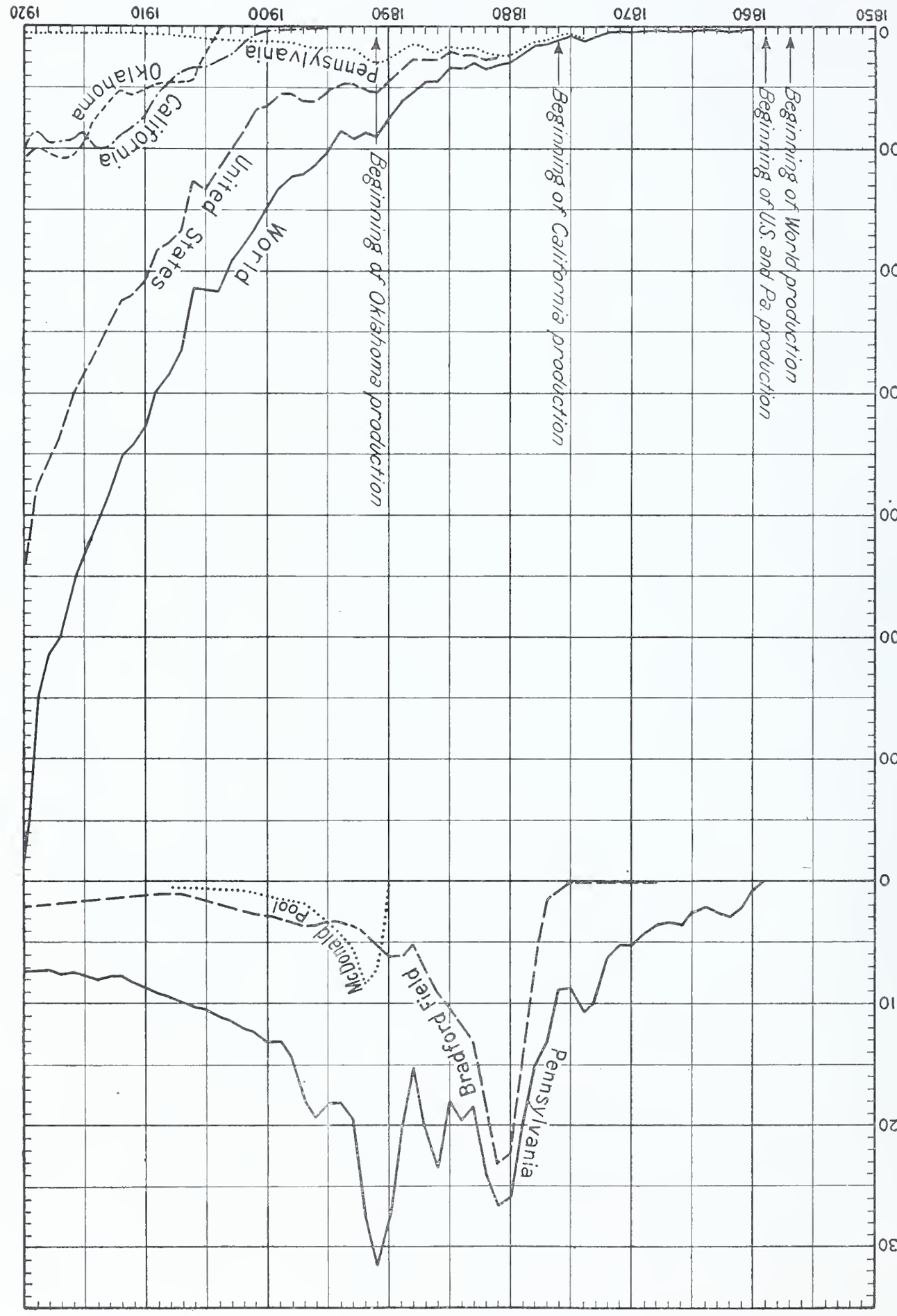


Fig. 8. Curves showing the yearly production of petroleum in: the world; the United States; California; Oklahoma; Pennsylvania; and the Bradford and McDonald pools in Pennsylvania.

NOTES ON THE OIL AND GAS POOLS OF PENNSYLVANIA.

EXPLANATION OF CHART OR TABLE.

A chart or table, on back of Plate I, has been prepared for use in conjunction with the map of this bulletin. The numbers in the first column on the chart correspond to the pool numbers on the map. The names of the pools are in the second column, above which the county names are seen in bold face type. It must be understood that no definite line can be drawn as to where one pool changes into the other, but for convenience the numbers are used.

Next comes the type of production, whether it be oil or gas or both. Then the initial production, which gives an idea as to the size of some of the wells in the various pools. The initial production is given in either barrels per day or cu. ft. per day. The rock pressure is sometimes given. In column five the date of discovery of a pool is seen. The next column gives the name of the producing sand or sands.

The remainder of the table shows the average distance from the Pittsburgh coal horizon to the various sands, together with the average thickness of each sand. One having a knowledge of the position of the Pittsburgh coal horizon can estimate the depth to various sands by use of the table. The structure contours on the map are based on the elevation of the Pittsburgh coal horizon, hence, knowing the surface elevation, the depth to drill to any of the sands on the chart can easily be calculated. For example, the Pittsburgh coal has an elevation of 1200 feet above sea level at Versailles, near McKeesport, Allegheny County, while the surface elevation along the railroad tracks is 765 feet above sea level, therefore, any well starting at this level would have to drill the distance shown on Chart under Pool No. 243, less (1200-765) 435 feet. Therefore the distance from the railroad track level to the Speechley sand at Versailles is 2835 feet.

The following are some general remarks relative to production of each pool, listed under county, number and name. While this information is not specific, it gives in a general way some idea as to what might be expected from the same, as well as giving a general idea as to what has happened in the past.

List of abbreviations used in text.

B. I.	Big Injun Sand
tk.	Thickness
1	First Sand
M	Murrysville Sand
50′	Fifty Foot Sand
2	Second Sand
100′	One Hundred Foot Sand
30′	Thirty Foot Sand
G. S.	Gordon Stray Sand
3	Third Sand
G	Gordon Sand
4	Fourth Sand
5	Fifth Sand
6	Sixth Sand
Bd.	Bayard Sand
Eliz.	Elizabeth sand
Sp.	Speechley Sand
Brad.	Bradford Sand
B. or bbl.	Barrel
R. P.	Rock pressure
L. P.	Line Pressure
″	Inch
Min.	Minute
Cu. ft.	Cubic feet

SHORT DESCRIPTION OF POOLS BY COUNTIES.

Erie County

Pools 1, 2 and 3 are one continuous field, that is, gas is obtained all along the lake front. Many oil showings have been encountered, one near Northeast yielding 15 bbls. per year. The oil and gas is obtained from Portage shales. The average depth below lake level is 1000 feet. Several wells have been drilled to the Medina (Clinton) sand and small quantities of gas obtained. Considerable drilling has been done inland but no paying quantities of either oil or gas have been found except along the lake front. The wells are of varied size, some having a rock pressure of from 8 to 10 lbs. with a volume of 10,000 cu. ft. per day and others with a pressure of 110 lbs. flowing 100,000

cu. ft. per day. Nearly all farmers along the lake shore have gas wells for their own conveniences and many manufacturing concerns have their own gas wells.

Warren County

Pool No. 4, Grand Valley. Old wells now on vacuum, and are making ¼ bbl. per day each. New wells 800 to 1000 feet deep with an initial production of 2 to 5 bbls. settle to about ⅕ bbl. per day. Some 400 wells in the pool.

Pool No. 5, Enterprise. Most of the wells are on vacuum, average production ⅛ bbl., while initial production of new wells is 2 bbls. per day.

Pool No. 6, Tidioute. Strong vacuum on most of the wells. Third and Fourth sands seem to have united. Initial production of new wells 2 bbls. per day. Ten producing wells in 1860.

Pool No. 7, Fagundus. Wells on vacuum.

Pool No. 8, Dennis Run. New wells making 1 to 2 bbls. at depths of 400 to 800 feet soon settle to ¼ bbl. Arranging to install pumps.

Pool No. 9, North Warren. Depth of wells 900 to 1500 feet. About 100 wells in field, some large at first, but all small now. The yearly record of three wells was in 1917, 152 bbls., in 1918, 238 bbls., and in 1919, 207 bbls. On February 4, 1921, it was reported that a strike of slush oil was made within the city limits of Warren at a depth of 475 feet. The well was bailing 100 bbls. of oil per 24 hours.

Slush oil, usually found at shallow depths, is common in this district. A number of years ago a slush well was struck in the city. It produced several hundred barrels of oil a day but was exhausted in about six weeks. Another was struck in 1915 and produced about 40 bbls. of oil a day for three or four days.

Pool No. 10, Glade Run. Wells now coming in at 10 to 12 bbls. per day at 750 to 900 feet in depth, settle at end of first year to ¼ bbl. per day. Good pressure on field yet. About 150 wells in field.

Pool No. 11, Wardwell. Wells in this field come in as high as 20 bbls. a day which settle at end of first year to 1 bbl. per day. In the valleys, wells are 950 feet deep and on the hilltops about 1400 feet. About 300 wells in the field.

Pool No. 12, Clarendon. Old wells which made 25 to 40 bbls. daily are now making ¼ to 1/10 bbl. Depth to pay 1250 feet in valleys. Nearly 2500 wells in pool. Sand rather hard. New wells making 15 bbls. per day settle to 1 bbl. at end of first year.

Pool No. 13, Dewdrop. Oil at 850 feet in depth. Wells made as high as 75 bbls. per day. Pool almost exhausted in 1897. Some little oil and gas obtained at present to the south.

Pool No. 14, Sheffield. Original wells made 20 million cubic feet per day under 700 lbs. rock pressure. Wells now making 35,000 cu. ft.

Pool No. 15, Cornplanter. Original wells made from 200 to 300 bbls. per day. Depth in the valley 1000 to 1100 feet. Some little oil and gas is obtained from the "Chipmunk" sand, average depth 500 to 600 feet. In March of 1916 near Kinzua, much activity was shown when a 15 bbl. oil well was completed. Oil was found in the Kane sand near Eldred in 1915.

Pool No. 16, Cherry Grove. A 2000 bbl. well was drilled in in this field some 37 years ago which only lasted a few months. Gas was obtained in several wells under 500 lbs. rock pressure, the wells making from 50 to 60 thousand cubic feet a day. The pool was flooded and practically exhausted in 1911.

General: Two wells drilled north of Garland. Oil showing at 1474 feet, not in paying quantities however.

A well drilled 720 feet deep near the New York State Line (May 8, 1920,) in Sugar Grove Township, is reported as making 10 bbls. of oil per day.

McKean County.

Pool No. 17, Lafayette. Some of the original wells made as high as 300 bbls. per day but have now settled to ½ to ¼ bbl. per day. Production from both Clarendon and Kane sands. About 120

McKean County, (Cont'd)

wells in the pool. A well making 50 bbls. a day in 1882 is now making ¼ bbl., and one making 35 bbls. a day in 1911 is now making ½ bbl.

Pool No. 18, Windfall. Wells 1100 feet deep with small production.

Pool No. 19, Sugar Run. The producing sand is called the "Dewdrop," and is about 900 feet below drainage. It is perhaps equivalent to the Tiona or Speechley. In 1915 the daily production of one well was 52.76 bbls., and the same well in 1916 produced 58.2 bbls. per day. In this field the record of 8 wells for the last four years was in 1917 a production of 2828.32 bbls., in 1918, 2462.71 bbls., in 1919, 1811.75 bbls., and for the first six months of 1920, 909.55 bbls.

Pool No. 20, Gilbert Run. Near New York State Line, with a depth of 1100 feet to well. Production small.

Pool No. 21, Bradford. Many big wells were drilled in old field, but most all of them have settled to ⅛ bbl. per day except in the flooded area where some of the wells are making as high as 50 bbls. per day. A well drilled in June, 1878, produced 150 bbls. a day for several days and is still producing ¼ bbl. a day. About 35,000 wells in the field. Nearly 60 wells are being completed each month. Production to January, 1886, 121,866,000 bbls.

Pool No. 22, Kushequa. Early wells had good production at 1900 feet. The pool is now being flooded. Average production per day is ⅙ bbl.

Pool No. 23, Ormsby. Original wells made about 200 bbls. per day from Bradford and Kane sands. They are now making on an average about ¼ bbl. a day except in flooded districts, where the production is better.

Pool No. 24, Wetmore. Average production per well is about ⅛ bbl. a day. Gas is obtained from Elk sand with a rock pressure of 350 lbs. and a volume of 50 thousand cu. ft. of gas per day.

Pool No. 25, Kane. Average daily production now per well is ¼ bbl. In July, 1920, a gas well was obtained within the borough limits of Kane, the estimated flow of which was 200 thousand cu. ft. per day.

Pool No. 26, Hazelhurst. Gas was obtained at 1800 feet while the oil comes at about 2000 feet. Oil wells now making about ⅛ bbl. a day.

Pool No. 27, Marvindale. Small gas field.

Pool No. 28, Smethport. A well that made 247 thousand cu. ft. at 400 lbs. rock pressure in 1915, now is making 50 thousand cu. ft. at 150 lbs. rock pressure. About 120 wells in field.

Pool No. 29, Colegrove. Volume from one well in 1918 was 24 thousand cu. ft. Some of the gas is from the Elk sand.

Pool No. 30, Betula. Small gas pool, opened up in 1864. Has spread over considerable territory since that time.

Potter County

Pool No. 31, Shinglehouse. Gas volume very small. A well in 1920 had a volume of 17,000 cu. ft. a day, while a well drilled in 1919 produced 537,600 cu. ft. a day.

Pool No. 32, Coudersport. A well in 1914 made 663,000 cu. ft. a day, while one in 1920 made 67,392 cu. ft. a day.

Tioga County

Pool No. 33, Gaines. Prospecting for oil and gas in this vicinity began in 1884 and continued more or less spasmodically until 1887 but with no encouraging results. In 1897-1898 drilling was revived, and at a depth of 700 to 900 feet oil and gas were obtained in what is known as the Atwell sand. Geologically, this sand is 700 feet below the base of the Catskill. About 200 feet above the Atwell sand, which is sometimes called "Dark" or "Black" sand, is the Blossburg formation, which is composed of shales, sand and limestones, from which both oil and gas were obtained. In the fall of 1915 a renewal of activities occurred in the Gaines field near Watrous.

In 1900, seventy wells had been drilled to the Atwell sand and 30 wells were producing from the Blossburg formation. Wells varied in pro-

Tioga County, (Cont'd)

duction from 2 to 5 bbls. a day to 2100 bbls. a day, the Blossburg formation yielding the larger wells, but these were soon exhausted. The Atwell sand was of fine grain, giving a small initial production but longer life than the wells in Blossburg. A well from the Blossburg formation made 2100 bbls. of oil a day, but within two months had dropped to 30 bbls. a day. The total production from this well did not exceed 30,000 bbls. of oil. The oil from both horizons was similar in quality, and was of good grade, 42° Baume. Gas in small quantities was obtained from both horizons, but was not used commercially.

Pool No. 34, Knoxville. In October of 1917 natural gas in fair volume and under a closed pressure of about 320 pounds to the square inch, was found near Knoxville.

Crawford County

Pool No. 35, Lake Creek. Production small still producing.

Pool No. 36, Titusville. Redrilling old field. Most of the wells are under very high suction. Some of the new wells are making 50 to 100 bbls. First oil well on Wilson's flats was struck at a depth of 69½ feet on August 28, 1859. In 1860 a 480 bbl. well was obtained at a depth of 143 feet.

Pool No. 37, Atlantic. Oil was struck at 500 feet. Much water. Pool of no importance.

Pool No. 38, Geneva. Small amount of gas. No oil.

General: A well producing five barrels of oil a day from the Second sand at 660 feet was reported on December 3, 1920. The well is located on the Gene Devoreat farm about two miles east of Meadville near the Titusville Road.

Mercer County

Pool No. 39, Greenville. Wells 600 to 700 feet in depth, but not very productive.

Pool No. 40, Mercer. Old, heavy, black oil. Not being operated at the present time.

Pool No. 41, Sharon. Wells are 500 to 600 feet deep. In 1900 eight wells produced oil and four gas. In 1905 the average production per well for oil was ½ bbl. and for gas 30 thousand cu. ft daily. New developments starting.

Pool No. 42, Volant. Wells 800 to 900 feet deep. Original (1905) wells produced 5 to 10 bbls. of oil a day. They are now producing from ¼ to 1 bbl. Much new drilling to north in 1910 obtained gas under 300 lbs. rock pressure with a daily volume of 100,000 cu. ft. Over 300 wells in field.

Pool No. 43, Wolf Creek. Small gas wells. In 1919 one well had a volume of 35 thousand cu. ft. a day.

Venango County.

Pool No. 44, Raymilton. Heavy oil. Original well produced 50 bbls. a day, but is now down to ⅛ to ¼ bbl. a day. Recent developments.

Pool No. 45, Bullion. One well in 1911 with a rock pressure of 184 lbs produced 290 thousand cu. ft. of gas a day. In 1915 the rock pressure of this well was down to 68 lbs. Oil wells with an original production of 25 bbls. a day are now listed at ⅛ bbl. a day.

Pool No. 46, Kennerdell. The rock pressure in 1911 was 184 lbs., but in 1915 was down to 68 lbs.

Pool No. 47, Fosters. Original wells made 20 bbls. a day but are now making ⅛ bbl.

Pool No. 48, Oil City. Oil obtained at 800 to 1000 feet. In 1916 one well made 6 bbls a day but soon settled to ½ bbl. Average daily production now ⅙ to ½ bbl. Gas is now being obtained from this pool. A well that came in in February, 1920 estimated at 100 thousand cu. ft. daily.

Pool No. 49, Shamburg. Original wells which came in at 100 bbls a day are now producing very little. Recent wells drilling in produce 2 to 4 bbls. per day but soon settle to from ⅛ to ½ bbl.

Pool No. 50, Pleasantville. Pumping water off of old territory at rate of 200 bbls a day. Plan-

Venango County, (Cont'd.)

ning to pump for several months when oil is expected.

Pool No. 51, Pithole. First wells in pool were large but short lived. Redrilling old area after water is all exhausted is expected to reclaim much oil.

Pool No. 52, Oleopolis. Small wells, almost exhausted now.

Pool No. 53, Cranberry. The production from this pool is from the Gray Sand (local). It comes about 90 feet below the Second Sand and perhaps is equivalent to the Thirty foot. Some wells made as much as 30 bbls a day. Wells coming in now making 1 to 5 bbls., soon settle to ⅛ bbl. a day.

Pool No. 54, Sandy Creek. Oil in this pool is obtained from the Red Valley sand, which is about midway between the First and Second sands. It has a thickness of about 20 feet. Oil production small. Gas is obtained from both the Third and Speechley sands. Rock pressure in 1919 was 160 lbs. and volume from one well was 46,000 cu. ft. a day.

Pool No. 55, Black Hill. The production has settled until at present it is very small. Much gasoline is made from the gas.

Pool No. 56, Emlenton. In 1914 the rock pressure was 140 lbs. One well had a flow of 120,000 cu. ft. a day. In 1915 the same well had a rock pressure of 120 lbs. with a flow of 111,000 cu. ft. Original wells made as high as 100 bbls. a day. New wells now coming in at 2 to 5 bbls. a day soon settle to 1 barrel a day. In May of 1916 a 100 bbl. well was drilled in on the Rumbarger farm, which resulted in much activity.

Pool No. 57, Utica. Heavy oil, production very small—1 to 2 bbls daily.

Pool No. 58, Sugar Creek. Heavy oil was obtained from First sand. Water conditions were bad and soon corroded the casing and tubing. Gas was obtained at 800 feet with small production which played out in 1913.

Pool No. 59, Franklin. From the First sand a very high grade oil was obtained which required no refining. Average well 1/10 to 1/12 bbl. a day. A black colored oil was obtained from the so-called Gray sand which is just above the Third sand. Wells were small. From the Third sand a green oil was obtained which was of about the same gravity as the black colored oil.

Pool No. 60. Wesley. Very small field.

Rock pressure record from the Gas sand in Slippery Rock, Worth, Cranberry and Marion Townships:

1896	—	205 lbs.
1897	—	200 lbs.
1899	—	390 lbs.
1909	—	174 lbs.
1910	—	250 lbs.
1913	—	200 lbs.
1914	—	135 lbs.
1919	—	128 lbs.

Rock pressure record from the same townships in the Boulder sand:

1905	—	260 lbs.
1907	—	275 lbs.
1909	—	224 lbs.
1910	—	230 lbs.
1912	—	220 lbs.
1913	—	250 lbs.
1914	—	252 lbs.
1918	—	96 lbs.
1919	—	84 lbs.

Note: One will wonder why the rock pressure in the same pool in a later year is recorded as higher than an earlier year. This, no doubt, is because when the pressure was taken, the well had been shut in; if allowed to flow for a time, the pressure doubtless would be even lower than the preceding year.

Forest County.

Pool No. 61, Golinza. A little oil is obtained from this pool. In July, 1918, the rock pressure was 35 lbs. and the volume 90,000 cu. ft. a day. In 1920 the volume had decreased to 28,000 cu. ft. a day from an individual well.

Forest County, (Cont'd)

Pool No. 62, Marienville. Small wells and much scattered.

Pool No. 63, Clarington. A well in 1918 made 53,000 cu. ft. a day. In 1920 the rock pressure was 165 lbs and a well made 25,000 cu. ft. a day.

Pool No. 64, West Hickory. Most of the production is from the First sand at a depth of 600 to 650 feet. In this pool 22 wells are now making 100 bbls of oil a month.

Pool No. 65, Tionesta. Small pool mostly from First sand at a depth of about 600 feet. Initial production now about one bbl. a day. In 1915 a new oil pool was discovered on Peter's Run in the borough of Tionesta. A well was started to test the Speechley sand, but at a depth of 600 feet a 50 barrel well was tapped in the Fourth sand. The pool was small and its limits soon outlined by drilling.

Pool No. 66, Endeavor. Small wells with rock pressure averaging 200 lbs. Volume per well about 30,000 cu. ft. per day.

Pool No. 67, Balltown. Many large wells when field was opened up, one of the wells in 1883 reported to have made 4,000 bbls. a day. The production was mostly from the Balltown, which is perhaps the same as the Gartland and Cherry Grove sands. About 300 wells in the field with an average production of ½ bbl each per day. The Balltown sand is about 1200 feet below the valleys. Gas in this field in 1917 was under a rock pressure of 610 lbs. A single well had a daily flow of 83,400 cubic feet.

Elk County

Pool No. 68, Hallton. While this is an old field, considerable drilling is now being done. Original wells made 3 million cu. ft. daily under 880 lbs. rock pressure. Wells are now making 60,000 cu. ft. daily under 450 lbs. rock pressure.

Pool No. 69, Ridgway. Production is obtained from the Speechley, Bradford and Kane sands. A well made 60,000 cu. ft. daily under 600 lbs. rock pressure in 1900 from the Bradford sand; in 1914 from the Kane sand a well made 8,227,000 cu. ft. under 935 lbs rock pressure; and in 1916 from the Speechley sand, a well made 221,000 cu. ft. under a rock pressure of 270 lbs. The latter well is now making 30,000 cu. ft. daily. The Ridgway gas field received much attention during 1916 when several wells of large capacity were completed.

Three miles south of Ridgway at Island Run a pool was opened in 1912 to the Speechley, Bradford and Kane sands, with the following record:

Daily production.

Year	Wells	Cubic feet
1913	4	169,623,000
1914	9	159,648,000
1915	11	184,342,000
1916	12	154,975,000
1917	12	166,245,000
1918	16	219,327,000
1919	16	185,780,000

Pool No. 70, Nansen. Some gas from the Kane sand. A well in 1918 had a volume of 824,000 cu. ft. a day under 480 lbs. rock pressure.

Pool No. 71, Sackett. Production from Bradford, Elk and Kane sands. A well in 1918 made ¾ bbl. of oil a day from Kane sand at a depth of 2500 feet. Between 400 and 500 wells in the field.

Pool No. 72, Mill Creek. Some gas from Tiona (Clarendon) sand and the Kane and Elk-Group sands. A well in 1904 made 860,000 cu. ft. a day under 625 lbs rock pressure. In 1919 the same well made 19,400 cu. ft. a day under 310 lbs. rock pressure.

Pool No. 73, Glenhazel. Small oil and gas wells. Depth about 1600 feet. In August of 1916 a 40 bbl. well was completed in this field. This is far above the average which ranges from 2 to 3 barrels initial capacity.

Pool No. 74, Bear Creek. Gas from both Bradford and Elk sands. Depth to Elk sand is 2530 feet. Original wells produced 3 million cu. ft. a day under 850 lbs. rock pressure. The present wells produce 103,000 cu. ft. a day under 635 lbs. rock pressure.

Pool No. 75, St. Marys. Small oil and gas field. Depth of wells about 1800 feet, with twenty wells in the field.

Clinton County

Pool No. 76, Hammersley Fork. Two wells drilled here, one to a depth of 1000 feet and the

Clinton County (Cont'd)

other to 1900 feet. These two wells produced 600,000 cu. ft. a day when first drilled. Just southeast of this pool at Hyner, two wells have been drilled, one on each side of the river. One well was drilled in 1880 and the other in 1905, and they produce sufficient gas for domestic use.

General: Considerable gas was found in 1903 near Hyner Station, near the central part of the county. A well was drilled to a depth of 2000 feet and reported as being located on good stucture. The rock pressure was 480 pounds to the square inch. Gas was also found nearby at 1222 feet and was reported as making two pounds pressure in a two inch pipe.

Lawrence County

Pool No. 77, Bessemer. Oil obtained at a depth of 850 feet. Some 50 wells in the pool averaging ½ bbl. a day per well.

Pool No. 78, Mt. Jackson. Gas from this pool used only for emergencies. Producing much water. Gas obtained from the Gas Sand at a depth of 560 feet, perhaps between the Berea and One Hundred Foot sands. No new developments. For the last twelve years the record of the rock pressure has been for 1904—100 lbs.; 1907—115 lbs.; 1910—185 lbs:; 1915—174 lbs.; 1916—140 lbs.; 1917—180 lbs.; 1918—174 lbs.; 1919—162 lbs.

Pool No. 79, Enon Valley. Small production, no new development. Depth 500 to 700 feet.

Pool No. 80, New Castle. Some deep tests to 3500 feet planned in the vicinity of New Castle. Old production was shallow, 800 to 900 feet. Well near mouth of Mahoning Creek flowed several barrels of oil in 1900.

Pool No. 81, Princeton. Small field. Depth 650 feet. Original volume of one well, 100,000 cu. ft. daily, now 10,000 cu. ft.—perhaps this is the only producing well.

Pool No. 82, Slippery Rock. Small oil production. Very small now.

Pool No. 83, Camp Run. Small pool.

Beaver County

Pool No. 84, New Galilee. Best wells in this pool were obtained in 1900. Daily production of new wells is from 3 to 4 bbls. Of the old wells, 100 produced 10 bbls. a day for the past year.

Pool No. 85, Bradys Run. Production is from Gas Sand at a depth of 950 feet, which comes 20 feet below the Berea and is about 15 feet thick. From 1890 to 1895 one hundred wells were drilled. Some made 3 million cu. ft. a day. Some 20 wells are now producing 15,000 cu. ft. each day.

Pressure in pounds by year.

Gas Sand	Berea Sand
1903—189 lbs.	1906—223 lbs.
1905—250	1907—220
1907—225	1916—136
1908—194	1919— 38
1909—255	
1910—249	
1911—147	
1913—140	
1915—211	
1916—183	
1919— 67	

Oil has been discovered five miles northwest of Beaver.

Pool No. 86, Smiths Ferry. Average settled production ¼ bbl a day. Four to six wells drilled within the last six months have an average initial production of one bbl a day each. The best well struck for years came in at 1000 feet on July 18, 1920.

Pool No. 87, Hookstown. Oil found at 1125 feet in depth. Old production about one barrel a well a day. New wells have an initial production of 3 to 4 bbls. Over 200 wells in the pool. In 1901 the pool revived somewhat when several 50 barrel wells were struck.

In 1913 an extension was noted to the north of the old Carson field in Hanover Township. Many wells yielded from 25 to 75 bbls. a day initial production. Toward the end of the year the extension was to the east near Hookstown, where a 10 bbl. well gave cause for further operations. On December 11, 1920 a well near Kendall was reported as making two bbls. of oil a day from the Berea sand.

Pool No. 88, New Sheffield. There were large wells in the early days under 600 lbs. rock pressure. In 1910 a well producing daily about 100,000 cu. ft. had a rock pressure of 600 lbs., and in 1920 a well producing 15,000 cu. ft. daily had a pressure of 20 lbs. About 100 wells in field.

Pool No. 89, Shannopin. About 1886, big wells came in, but field has been on the decline since. Present production small, 1 bbl or less. Some

Beaver County, (Cont'd)

600 to 800 wells were drilled in this pool. On January 27, 1921, a 40 bbl. oil well was struck in Independence Township, near South Height.

Pool No. 90, Economy. This pool produced both oil and gas from the Hundred Foot sand, at a depth of 1525 feet. Early wells made as high as 500 bbls. a day, but the average was from 40 to 50 bbls. a day. Present production is but ½ bbl. a day. About 200 wells were drilled in this pool, and on account of the gas being from the same sand, many of the wells flowed naturally. The pressure in 1908 was 520 lbs.; in 1917 it had dropped to 240 lbs., and in 1919 to 53 lbs.

Pool No. 91, Cookson. Small oil pool. Gas pressure about the same as in pool No. 90. Not many wells in the pool.

Pool No. 92, Crows Run. Some gas was obtained from the Boulder sand. Three distinct pay streaks in the Hundred Foot sand. Many of the wells yielded from 300 to 500 bbls. a day and a large number exceeded 100 bbls. a day. Wells are now small producers.

Pool No. 93, Monaca. There were 8 producers in 1917 in all making 100,000 cu. ft. a day, or an average of 12,500 cu. ft. each. The combined present production of six of these wells is 66,000 cu. ft. a day.

Butler County

Pool No. 94, Harrisville. Small gas pool. Production mostly from the Hundred Foot sand.

Pool No. 95, West Liberty. Gas was obtained from the Berea or Murrysville sands, while the oil came from the One Hundred Foot sand. Practically no oil produced now but considerable gas. On July 1, 1920 a million foot well came in. On December 25, 1920, the Central Oil and Gas Company reported a five bbl. well on the Carrall Brothers farm in Worth Township.

A well near Slippery Rock was completed January 2, 1921, with a pressure of 260 lbs. Six wells recently completed are producing together three million cu. ft. of gas a day.

Pool No. 96, Muddy Creek. On January 1, 1891, the discovery well was completed. By April 7, 1891, six wells were producing 125 barrels of oil a day. This pool is still productive.

Pool No. 97, Zelienople. Depth to pay oil in this pool 1400 to 1500 feet. Some gas wells came in in 1900 with a rock pressure of 225 bbls. from the Thirty Foot sand, which increased in 1914 to 645 lbs. and produced 700,000 cu. ft. a day.

Pool No. 98, Glade. Small wells. (See Pool No. 99.) On September 15, 1920, a gas well came in in Third Sand, and a 3 bbl. oil well in the Hundred Foot sand. November 25, 1920, a 20 bbl. oil producer in the Hundred Foot sand and a smaller gasser in the Boulder, and a 5 bbl. pumper in the Berea were completed.

Pool No. 99, Thorn Creek. Production record for six years:

1914	50 wells—9,417 bbls.
1915	50 wells—8,875 bbls.
1916	48 wells—7,939 bbls.
1917	43 wells—6,275 bbls.
1918	37 wells—5,678 bbls.
1919	36 wells—5,534 bbls.

It was reported in 1905 that a well three miles west of Butler flowed 250 bbls. of oil in three hours. At the end of the first week the well was making 30 bbls. of oil an hour. Many small and many dry wells were drilled. The productive area proved to be very small.

Pool No. 100, Butler. Some gas from the Berea sand at 1130 feet in depth. A well tubed with 3″ pipe gave the following pressures after blowing open for thirty minutes:

Year	1 min.	5 min.	10 min.	15 min.	30 min.
1913	3 lbs.	14 lbs.	24 lbs.	42 lbs.	50 lbs.
1914	2	7	18	18	29
1915	2	8	15	19	28
1916	1	6	11	14	22
1917	--	3	9	11	14
1918	--	6	8	11	14
1919	--	4	6	8	10

Butler County (Cont'd)

In 1920 a gas well was reported as making two million cu. ft. daily under 206 lbs. rock pressure.

Pool No. 101, Glade Mills. Oil was reached at about 1900 feet. Production record for ten years:

1910—19 wells	—9,016 bbls.
1911—18 wells	—6,059 bbls.
1912—18 wells	—4,638 bbls.
1913—19 wells	—4,170 bbls.
1914—18 wells	—5,553 bbls.
1915—17 wells	—6,510 bbls.
1916—15 wells	—2,418 bbls.
1917—14 wells	—2,173 bbls.
1918—12 wells	—1,906 bbls.
1919—11 wells	—2,010 bbls.

On December 25, 1920, a 30 bbl. well was reported near Brownsdale. The oil was obtained from the Hundred Foot sand. Two pays were encountered.

Pool No. 102, Evans City. In 1899 wells were obtained producing 20 bbls. a day from the Hundred Foot sand at a depth of 1500 feet. Small quantities of gas were obtained from both the Hundred Foot and Thirty Foot sands. In 1915 a well drilled on the Lutheran Church lot had an initial production of 200 bbls. a day from the Third sand. In a very short time the village was full of derricks, and needless to say the results were similar to most town lot developments. The maximum daily production was about 1500 bbls., which occurred in August of that year. About 150 wells were drilled in this pool.

Pool No. 103, Ramsey. Considerable salt water was obtained with the oil. Depth to pay about 1500 feet.

Pool No. 104, Callery. Similar to Pool No. 103.

Pool No. 105, Carvin. Large quantities of oil were obtained from this pool with a little gas. In 1915 a well was making 230,000 cu. ft. a day under 380 lbs. rock pressure.

Pool No. 106, Criders. Oil was obtained from both the Hundred Foot and Snee sands, and considerable quantities of gas were gotten from the Boulder sand.

Pool No. 107, Peters. Gas in small quantities was obtained from the Hundred Foot sand.

Pool No. 108, Mars. In this pool three distinct pays were recorded within the Hundred Foot sand, the first two being oil, and the third gas. No production below the Hundred Foot.

Pool No. 109, Clintonville. Small production. In 1913 under 250 lbs. rock pressure, 55,000 cu. ft. of gas were obtained.

Pool No. 110, Seaton Creek. Some gas from the Speechley sand at 2300 feet deep, averaging 60,000 cu. ft. daily under 275 lbs. rock pressure. A well producing 10 bbls. of oil a day was drilled in on August, 1920.

Pool No. 111, Rosenberg. A well making 15 bbls. of oil a day in 1916 was exhausted in 1919.

Pool No. 112, North Washington. In 1894 several good wells were struck and quite an important pool was opened up.

Pool No. 113, Petrolia. Very large pool. Oil from Thirty Foot, Fifth and Speechley sands. Production for six years:

1914—11 wells	—2,030 bbls.
1915— 9 wells	—1,567 bbls.
1916— 9 wells	—1,278 bbls.
1917— 9 wells	— 847 bbls.
1918— 9 wells	— 817 bbls.
1919— 4 wells	— 287 bbls.

A record of eight years of gas from the Speechley sand at 5 minute pressure in a $6\frac{1}{4}$ inch casing:

1913—10 lbs	1917—19 lbs
1914—45 lbs	1918—20 lbs
1915—25 lbs	1919—13 lbs
1916—25 lbs	1920—18 lbs

A well drilled into the Hundred Foot sand was reported December 4, 1920 to be producing 2 million cu. ft. of gas daily. This well is located near Fenelton.

Pool No. 114, Butler Cross Belt. Similar to Pool No. 113.

Pool No. 115, Concord. Production from nearly all of the sands. The record for eight years:

1912—6 wells—1,749 bbls.	1916—6 well —1,453 bbls.
1913—6 wells—1,643 bbls.	1917—6 wells—1,492 bbls.
1914—6 wells—1,543 bbls.	1918—6 wells—1,339 bbls
1915—6 wells—1,568 bbls.	1919—7 wells—1,968 bbls.

Gas was obtained under 480 lbs R. P. in 1913 and in 1915. The 5 minute pressure was as follows:

Butler County (Cont'd)

1917—20 lbs.
1918—19 lbs.
1919—18 lbs.
1920—10 lbs.

Pool No. 116, Unionville. Small gas pool.

Pool No. 117, Crooked Run. See Pool No. 109.

Pool No. 118, Oneida. Oil from Hundred Foot sand. Gas from Third and Speechley sands. Record of production of oil for 10 years and the record of 5 minute pressures for 6 years in the gas well:

12 wells in 1910— 2,666 bbls.	1913—5 min—90 pounds
11 wells in 1911— 2,722 bbls.	1916—5 min—46 pounds
11 wells in 1912— 2,615 bbls.	1917—5 min—30 pounds
14 wells in 1913—14,816 bbls.	1918—5 min—26 pounds
27 wells in 1914—12,924 bbls.	1919—5 min—26 pounds
35 wells in 1915— 8,183 bbls.	1920—5 min—22 pounds
26 wells in 1916— 5,143 bbls.	
24 wells in 1917— 4,999 bbls.	
23 wells in 1918— 3,635 bbls.	Rock Pressure in 1913 was
21 wells in 1919— 3,063 bbls.	330 pounds.

Pool No. 119, Summit. Oil from Hundred Foot sand. Gas from Berea, Fourth and Speechley sands. Record for 10 years:

1910—15 wells—4,750 bbls.	1915—12 wells— 5,176 bbls.
1911—17 wells—3,951 bbls.	1916—14 wells— 9,669 bbls.
1912—16 wells—3,397 bbls.	1917—17 wells—10,221 bbls.
1913—14 wells—3,850 bbls.	1918—18 wells— 8,130 bbls.
1914—13 wells—4,164 bbls.	1919—20 wells— 6,687 bbls.

Gas obtained largely from Fourth sand—6¼ inch casing. Record for 10 years at 5, 10, 15 and 30 minute intervals:

	5 min.	10 min.	15 min.	30 min.
1910	5 lbs	9 lbs	14 lbs	24 lbs
1911	9 lbs	11 lbs	13 lbs	20 lbs
1912	3 lbs	5 lbs	7 lbs	13 lbs
1916	14 lbs	16 lbs		
1917	4 lbs			
1918	15 lbs	16 lbs	17 lbs	
1919	6 lbs	9 lbs	11 lbs	
1920	5 lbs	6 lbs	7 lbs	

Pool No. 120, Saxonburg. Gas from the First, Hundred Foot and Fifth sands. Oil from Hundred Foot and Fourth sands. Record for 10 years of the oil from this pool:

1910—24 wells—10,844 bbls.	1915—23 wells—8,983 bbls.
1911—31 wells—13,679 bbls.	1916—23 wells—8,578 bbls.
1912—30 wells—13,827 bbls.	1917—23 wells—8,482 bbls.
1913—28 wells—10,867 bbls.	1918—23 wells—8,062 bbls.
1914—25 wells— 9,392 bbls.	1919—23 wells—8,955 bbls.

Pool No. 121, Bakerstown. Oil from Fourth sand. Record of 7 years:

1913—25 wells—10,120 bbls.	1917—20 wells— 5,881 bbls.
1914—25 wells— 8,379 bbls.	1918—19 wells— 3,350 bbls.
1915—24 wells— 5,797 bbls.	1919—18 wells— 2,834 bbls.
1916—22 wells— 5,111 bbls.	

Pool No. 122, Clinton Township. Pressure in 5 inch tubing in 1900, and in 2 inch tubing 1903-1920:

	1 min	5 min	10 min	15 min	30 min	60 min	R. P.
1900	3 lbs	16 lbs	29 lbs	47 lbs	92 lbs	100 lbs	930 lbs
1903	8 lbs	18 lbs	25 lbs	32 lbs	305 lbs	400 lbs	605 lbs
1910	1 lb	5 lbs	10 lbs	15 lbs	29 lbs	58 lbs	106 lbs
1912		8 lbs	16 lbs	23 lbs	44 lbs		98 lbs
1913		6 lbs	11 lbs	16 lbs	32 lbs		88 lbs
1917	9 lbs	17 lbs	27 lbs				
1919		20 lbs	29 lbs	36 lbs			49 lbs
1920		14 lbs	22 lbs	30 lbs			

In 1902 the volume from the Thirty Foot and Speechley sand was 1¼ million cubic feet.

Pool No. 123, Winfield. Gas mostly from the Fifth sand. Record for three years in a 6¼ inch and a 3 inch pipe:

	6¼" Pipe	5 min	10 min	15 min	30 min
1918		5 lbs	11 lbs	16 lbs	23 lbs
	3" Pipe				
1919		15 lbs	19 lbs	22 lbs	
1920		13 lbs	17 lbs		

Rock pressure in Liberty and Marion Townships in Thirty Foot sand:

1905	1907	1912	1914	1919
160 lbs	255 lbs	385 lbs	140 lbs	90 lbs

Rock pressure in Allegheny and Crawford Townships in the Third sand:

1904	1905	1908	1909	1919
300 lbs	250 lbs	340 lbs	340 lbs	87 lbs

General: On December 10, 1920, a well was reported making a quarter million cu. ft. of gas daily on the Amos Young farm in Clay Township. This was the second well in this vicinity in ten days.

Clarion County.

Pool No. 124, Kossuth. In December, 1918, the rock pressure was 423 lbs. In September, 1919, it had decreased to 305 lbs., producing about 40,000 cu. ft. a day per well.

Pool No. 125, Beall. Six years' record of production, from one well mostly from the Speechley sand:

1902	2,800,000 cu ft	900 lbs R. P.
1914	240,000 cu ft	
1917	80,000 cu ft	330 lbs R. P.
1918	70,000 cu ft	
1919	17,000 cu ft	140 lbs R. P.
1920	10,000 cu ft	110 lbs R. P.

Clarion County (Cont'd)

Pool No. 126, Elk City. Some oil from all the sands. Large production of both oil and gas.

Pool No. 127, Manor In 1913 a well producing 1½ million cu. ft. was completed. Very little drilling is being done in this pool now.

Pool No. 128, Fryburg. In 1918 a well made 130,000 cu. ft. a day under 525 lbs. rock pressure, while in 1920 the same well made 27,100 cu. ft. a day under 325 lbs. rock pressure.

Pool No. 129, Leeper. A well in 1918 made 90,000 cu. ft. a day under 680 lbs. rock pressure.

Pool No. 130, Pine Grove. In 1913 a well made 341,000 cu. ft. a day under 530 lbs. rock pressure. In 1918 the rock pressure had declined to 135 lbs.

Pool No. 131, Lucinda. A well in 1920 made 70,500 cu. ft. a day under 700 lbs. rock pressure.

Pool No. 132, Miola. Oil wells that had an original production (1906) of 300 bbls. a day are now settled to ⅛ bbl. a day. Many of the gas wells made as high as 4 million cu. ft. a day; most of them are now abandoned. The gas was from the Speechley sand.

Pool No. 133, Clarion. In 1903 a well produced 2½ million cu. ft. a day under 925 lbs. rock pressure. In 1906 a well made 83,000 cu. ft. a day under 425 lbs. pressure. Five years' record of one well follows:

1914	182,000 cu ft	1918	120,000 cu ft	450 lbs. R. P.
1916	178,000 cu ft	1920	75,000 cu ft	225 lbs. R. P.
1917	80,000 cu ft			

Pool No. 134, Shamburg. Some gas from the Boulder sand. Rock pressure in 1905 was 120 lbs. A little oil came from Third and Fifth sands.

Pool No. 135, Sligo. Pressures from 2 inch tubing. Gas sand (below Berea).

	L. P.	1 min	2 min	3 min	4 min	5 min	30 min
1/ 6/12	92 lbs	198 lbs	226 lbs	238 lbs	245 lbs	250 lbs	
8/13/13	89 lbs	108 lbs	112 lbs	114 lbs	115 lbs	116 lbs	
9/17/15	44 lbs	50 lbs	66 lbs	68 lbs	70 lbs	72 lbs	75 lbs
4/18/16	14 lbs	26 lbs	32 lbs	36 lbs	40 lbs	42 lbs	53 lbs
6/24/19		24 lbs				28 lbs	47 lbs

Pressures from Hundred Foot sand from 6¼ inch pipe:

11/30/12	86 lbs	88 lbs	90 lbs	92 lbs	94 lbs	95 lbs	119 lbs
1/31/13	90 lbs	92 lbs	94 lbs	95 lbs	97 lbs	98 lbs	122 lbs
8/31/14	34 lbs	35 lbs	36 lbs	37 lbs	38 lbs	39 lbs	58 lbs
9/17/15	44 lbs					49 lbs	68 lbs
8/24/16	8 lbs	9 lbs	10 lbs	11 lbs	12 lbs	13 lbs	33 lbs
3/22/18	21 lbs					24 lbs	39 lbs
12/19/19	21 lbs					23 lbs	30 lbs

Pool No. 136, Kiefer. Record from Speechley sand for three years:

1910—422,108 cu. ft.—R. P. 470 lbs.
1916— —R. P. 263 lbs.
1920—297,089 cu. ft.—R. P. 260 lbs.

Pool No. 137, Greenville. Much drilling has been done over the entire township (Limestone). In 1916 a well made 342,330 cu. ft. under 710 lbs. rock pressure from the Bradford sand. The Greenville pool is located on the Kellersburg anticline and obtains most of its gas from the Speechley sand. Many wells made as much as 10 million cu. ft. of gas daily with a rock pressure of 900 lbs. to the square inch.

Pool No. 138, Frogtown. In 1916 a well made 83,000 cu. ft. under 350 lbs. rock pressure and in February of 1920 the same well made 2,200 cu. ft. under 191 lbs. rock pressure.

Pool No. 139, Mill Creek. Small gas production from the Murrysville sand.

Pool No. 140, Cherry Run. Prior to 1911, several gas wells were drilled along Cherry Run, the production being from Nineveh, Thirty foot and Hundred Foot sands. Gas was obtained as far back as the year 1878.

Pool No. 141, Fiddlers Run. A few scattered gas wells drilled several years ago obtained small quantities of gas from the Fourth sand.

Pool No. 142, Catfish Run. Small quantities of gas obtained from the First, Hundred Foot, Fourth and Speechley sands. A little oil was also obtained in this vicinity.

Pool No. 143, Rimersburg. A recent well made 33,200 cu. ft. of gas a day under 730 lbs. rock pressure.

Pool No. 144, Bittenbender. Very productive pool. This field obtains its production from the Hundred Foot sand.

Pool No. 145, Blair. Some oil and gas from the Hundred Foot sand. A little gas from the Bradford sand. A well in 1919 was making 40,000 cu. ft. a day under 595 lbs. rock pressure. Some oil from Murrysville sand.

Pool No. 146, Piollett. In 1917 a well made 455,000 cu. ft. a day under 540 lbs. rock pressure from the Speechley sand. In 1919 the gas had a pressure of 45 lbs. in the Thirty Foot sand.

Clarion County, (Cont'd)

Pool No. 147, New Bethlehem. Late in 1917 a 100 bbl. oil well was completed near New Bethlehem in Red Bank Township. This production was from the Hundred Foot sand at a depth of 800 feet. The oil obtained was amber in color, tested 43 deg. Baume, and commanded a premium of 25c. a barrel over Pennsylvania standard grade of oil (Reported). In 1919 a well was making 134,400 cu. ft. of gas a day under 75 lbs. rock pressure. This same well made 2 bbls. of oil a day.

Pool No. 148, Shannondale. Gas and oil are obtained from the Hundred Foot sand. Gas from the Speechley and Sheffield (between the Tiona and Bradford sands) and the Bradford sands. In 1906 a well in the Sheffield sand made 224,064 cu. ft. of gas a day under 465 lbs. rock pressure. In 1908 from the Hundred Foot sand a well made 800,000 cu. ft. of gas a day; in 1911 from the Speechley sand a well made 213,000 cu. ft. a day; and in 1920 a well made 170,000 cu. ft. a day.

Average pressures in various sands in this pool:

1913	Sheffield Sand	R. P. 407 lbs
1914	Hundred Foot	R. P. 278 lbs
1915	Sheffield	R. P. 413 lbs
	Hundred Foot	R. P. 260 lbs
1916	Bradford	R. P. 410 lbs
1917	Hundred Foot	R. P. 165 lbs
	Bradford	R. P. 335 lbs
1918	Hundred Foot	R. P. 67 lbs
	Bradford	R. P. 400 lbs

In 1918 a Speechley sand well made 106,000 cu. ft. a day under 650 lbs. rock pressure, and an oil well from the Hundred Foot sand made 100 barrels of oil a day.

Armstrong County.

Pool No. 149, Sherrett. A well in 1918 made 107,000 cu. ft. of gas a day under 590 lbs. rock pressure.

Pool No. 150, French Corner. A well in 1908 made 800,000 cu. ft. of gas a day, which in 1920 declined to 159,800 cu. ft. under 595 lbs. rock pressure. Some little gas obtained from the Fourth and Fifth sands.

Pool No. 151, Limestone Run. Gas was developed in 1875. Supply was obtained from the Hundred Foot sand. Later gas was obtained from the Speechley sand.

Pool No. 152, North Buffalo. In 1905 a well made 684,000 cu. ft. of gas a day. The pressure for 14 years in a 5 inch pipe follows:

	L. P.	1 min.	5 min.	10 min.	15 min.	R. P.
1903						615 lbs
1/23/04	80 lbs	97 lbs				256 lbs
3/30/06	18 lbs	25 lbs	29 lbs	35 lb	48 lbs	185 lbs
3/19/08	40 lbs	43 lbs	51 lbs	59 lbs	66 lbs	
10/11/09	25 lbs	27 lbs	55 lbs	41 lbs	47 lbs	
11/27/10	1 lb	3 lbs	9 lbs	16 lbs		
1/30/11	22 lbs	24 lbs	30 lbs	36 lbs		
3/19/12	12 lbs	14 lbs	19 lbs	25 lbs		
3/ 2/14	11 lbs	12 lbs	17 lbs	29 lbs		
7/12/15	23 lbs		28 lbs	32 lbs	36 lbs	
8/28/16	17 lbs		22 lbs	27 lbs	30 lbs	
5/10/17	13 lbs	14 lbs	17 lbs	21 lbs		
3/20/18	18 lbs		23 lbs	28 lbs		
6/25/19	17 lbs		22 lbs	27 lbs	30 lbs	
7/12/20	9 lbs		13 lbs	17 lbs	20 lbs	

Pool No. 153, Slate Lick. Pressures in a 3 inch pipe:

	L. P.	5 min.	10 min.	R. P.
1907				415 lbs
2/ 8/08	36 lbs	42 lbs	47 lbs	300 lbs
4/30/09	20 lbs	25 lbs	30 lbs	226 lbs
10/14/10	2 lbs	8 lbs	14 lbs	
4/ 6/11	5 lbs	20 lbs	35 lbs	
9/20/11	24 lbs	32 lbs	39 lbs	
11/21/12	6 lbs	9 lbs	12 lbs	
1/13/13	8 lbs	15 lbs	22 lbs	
5/22/14	27 lbs	32 lbs	37 lbs	
1/ 3/17	12 lbs	17 lbs	22 lbs	
3/11/19	14 lbs	15 lbs	17 lbs	
4/14/20	8 lbs	9 lbs	10 lbs	

A well was completed September 27, 1920, near Craigsville at a depth of 1200 feet, producing 3 million cu. ft. a day.

Pool No. 154, Freeport. Record of pressures follows:

	L. P.	1 min	2 min	3 min	4 min	5 min	10 min	R. P.
1910								300
8/ 9/11	28 lbs	30 lbs	32 lbs	34 lbs	36 lbs	38 lbs	48 lbs	
1/ 3/12	12 lbs	14 lbs	16 lbs	17 lbs	18 lbs	19 lbs	26 lbs	385
6/ 4/13	37 lbs	38 lbs	39 lbs	40 lbs	41 lbs	42 lbs	47 lbs	
11/24/14	19 lbs	20 lbs	21 lbs	22 lbs	23 lbs	24 lbs	31 lbs	
11/24/15	18 lbs	19 lbs	20 lbs	21 lbs	22 lbs	23 lbs	30 lbs	
11/24/16	11 lbs	12 lbs	13 lbs	14 lbs	15 lbs	16 lbs	21 lbs	
5/11/18	—	1 lb.				5 lbs	10 lbs	
1/22/19	10 lbs					22 lbs	32 lbs	
1/ 7/20	7 lbs					12 lbs	17 lbs	

Armstrong County, (Cont'd)

Pool No. 155, Madison. In 1902 the rock pressure was 270 lbs. in a well. This was increased to 330 lbs. in 1905.

Pool No. 156, Mahoning Furnace. In 1904 a well made 368,640 cu. ft. of gas a day under 110 lbs. rock pressure. In 1913 the pressure in this well was 81 lbs, increasing in 1914 to 136 lbs. In 1915 this well was exhausted.

Pool No. 157, Little Mud Lick Creek. A well in 1908 made 243,630 cu. ft. of gas a day under 400 lbs. rock pressure.

Pool No. 158, New Salem. A well in 1905 made 67,392 cu. ft. of gas a day under 223 lbs. rock pressure from the shallow sands. In 1911 a well from all sands made 622,000 cu. ft. of gas a day under 940 lbs. rock pressure.

Pool No. 159, McCrea Furnace. In 1908 a well made 894,000 cu. ft. of gas under 500 lbs. rock pressure.

Pool No. 160, Goheenville. Original wells made as high as 12 million cu. ft. a day. Later wells produced one-half million cu. ft. a day under 563 lbs rock pressure. In 1917 the rock pressure was 442 lbs.

Pool No. 161, Cowanshannock. In 1902 a well made 536,000 cu. ft. a day. In 1917 a well made 106,000 cu. ft. a day, the same well making 83,000 cu. ft. in 1919, and 95,000 cu. ft. a day in 1920.

Pool No. 162, Ford City. Pressures in a 5 inch tubing follow:

	L. P.	5 min.	10 min.	15 min.	30 min.
7-25-11	28 lbs	36 lbs	41 lbs		
6- 2-12	36 lbs	42 lbs	48 lbs		
1-24-13	42 lbs	50 lbs	55 lbs		
9-10-14	20 lbs	25 lbs	30 lbs		
11-23-15	28 lbs	31 lbs	33 lbs	36 lbs	
12- 7-16	30 lbs	35 lbs	39 lbs	42 lbs	
6- 1-18	21 lbs	26 lbs	29 lbs	32 lbs	
7-25-19	32 lbs	35 lbs	37 lbs	38 lbs	42 lbs
8- 5-19	28 lbs	30 lbs	31 lbs	32 lbs	34 lbs

Pool No. 163, Rockville. Small amount of gas, mostly from the shallow sands. Minute pressures in a 3 inch pipe in 1919:

1 min.	2 min.	3 min.	4 min.	5 min.	10 min.	15 min.	60 min.
2 lbs	4 lbs	6 lbs	8 lbs	10 lbs	18 lbs	25 lbs	92 lbs

The same well in 1920 against a line pressure of 20 lbs showed:
5 min.—26 lbs; 10 min.—32 lbs; 15 min.—38 lbs.

Pool No. 164, Atwood. A well in 1890 made 1,734,000 cu. ft. a day, while in 1920 the same well was making but 12,000 cu. ft. a day. A well that in 1908 was making 54,000 cu. ft. a day declined to 28,000 cu. ft. in 1920, and another that was making 54,000 cu. ft. a day in 1912 declined to 20,000 cu. ft. a day in 1920.

Pool No. 165, Say. In 1898 a well made 67,392 cu. ft. of gas a day under 60 lbs. rock pressure. In 1907 a well made 261,000 cu. ft. a day. In 1914 the rock pressure was 31 lbs.

Pool No. 166, Johnetta. In 1903 a well made 400,000 cu. ft. of gas a day from the Hundred Foot sand. In 1912 a well made 128,000 cu. ft. a day from the Fifth sand.

Pool No. 167, Leechburg. Gas in large volume was struck at a depth of 1250 ft. in a well drilled across the river from Leechburg in 1871. A small gas pool was discovered in Gilpin Township about 1900. The production was mostly from the Murrysville and Hundred Foot sands.

Pool No. 168, Vandergrift. In 1911 a well produced from the Thirty Foot and Bradford sands 375,000 cu. ft. of gas a day. This decreased in 1919 to 83,000 cu. ft. a day and in 1920 to 67,000 cu. ft. In 1916 the rock pressure was 375 lbs.

Pool No. 169, Shellhammer. Minute pressures in a three inch tubing:

	1 min.	2 min.	3 min.	4 min.	5 min.	30 min.
1917	5 lbs.	8 lbs.	11 lbs.	14 lbs.	16 lbs.	75 lbs.
1918	2 lbs.	4 lbs.	5 lbs.	7 lbs.	8 lbs.	40 lbs.
1919	7 lbs.					34 lbs.

In 1919 the Hundred Foot gas was exhausted. Flow from Bradford.

Pool No. 170, Girty. Most of the wells are in the Murrysville sand, the average production of each is 60,000 to 70,000 cu. ft. a day.

Pool No. 171, Plum Creek. In 1917 a well made 150,720 cu. ft. of gas a day with a rock pressure of 130 lbs.

Pool No. 172, Roaring Run. Rock pressure in 1915 was 140 lbs. A well in the Bradford sand in 1917 made 206,000 cu. ft. of gas a day. In 1919 it declined to 67,000 cu. ft. and in 1920 to 34,000 cu. ft. a day.

Pool No. 173, Apollo. A well in 1902 produced 513,000 cu. ft. of gas a day from the Speech-

Armstrong County, (Cont'd)

ley sand. This well was abandoned in 1905. In 1903 a well produced 140,000 cu. ft. a day. A well in 1907 was producing 510,000 cu. ft. a day, which had decreased in 1920 to 187,000 cu. ft. A well in 1912 was making 150,000 cu. ft. daily. A well in 1916 was making 450,000 cu. ft. of gas daily, while in 1920 the same well was producing but 84,000 cu. ft. a day.

Jefferson County

Pool No. 174, Sigel. A well in 1909 made 450,000 cu. ft. of gas a day with 800 lbs. rock pressure. In April, 1920, the same well was making 24,800 cu. ft. a day with 120 lbs. rock pressure.

Pool No. 175, Millstone. A well in 1918 made 183,000 cu. ft. of gas a day. In 1920 the same well made 100,000 cu. ft. a day under 450 lbs. rock pressure.

Pool No. 176, Howe. A well in 1919 made 564,000 cu. ft. of gas a day, with a rock pressure of 355 lbs. In April of 1920 the same well made 315,400 cu. ft. of gas a day under 225 lbs. rock pressure.

Pool No. 177, Warsaw. In the eastern part of this pool there was shallow gas at 950 feet. Some wells made as high as 5 million cu. ft. a day. Many wells were making 100,000 cu. ft. a day and better, with 50 to 100 wells in the pool. Rock pressure in 1919 was 640 lbs. On April 5, 1920, a well was drilled to the deep sand which produced 1½ million cu. ft. of gas. A well was reported completed on July 5, 1920, at 800 feet, which produced four million cu. ft. of gas.

Pool No. 178, Brookville. A well in 1911 had a flow of 620,000 cu. ft. of gas with a rock pressure of 950 lbs. In October, 1920, the pressure was 170 lbs. and much trouble was being experienced on account of water. A four million cu. ft. well at 1800 feet was reported in July, 1920. On December 24, 1920, it was reported a one million cu. ft. gas well came in on the Daniel Rhodes farm in Knox Township. The gas was obtained at 1010 feet from one of the Clarion sands which was an unusual well at this depth.

Pool No. 179, Oliveburg. The 1917 rock pressure was 565 lbs. Pressure April 1, 1917—470 lbs.; January 28, 1919—450 lbs.; and December 1, 1919—410 lbs. Gas at 1200 feet. In July of 1920 a two million cu. ft. well was drilled in at 3000 feet.

Pool No. 180, North Point. In 1919 a well was making 262,000 cu. ft. of gas daily which decreased to 31,400 in 1920, with a rock pressure of 165 lbs. The record follows for minute pressures in a 2 inch pipe:

	L. P.	1 min	2 min	3 min	4 min	5 min	10 min	30 min
1-20-12	83 lbs	105 lbs	125 lbs	155 lbs	175 lbs	195 lbs	275 lbs	
5-21-13	36 lbs	39 lbs	43 lbs	46 lbs	49 lbs	52 lbs	65 lbs	98 lbs
10-28-14	28 lbs					29 lbs	30 lbs	35 lbs
7-29-16	20 lbs	21 lbs	22 lbs	23 lbs	24 lbs	25 lbs	27 lbs	33 lbs
8- 7-17	18 lbs					19 lbs	20 lbs	24 lbs
3-11-18	18 lbs					19 lbs	20 lbs	24 lbs
7- 5-19	16 lbs					19 lbs	21 lbs	29 lbs

Open flow 1920, open 7 hours:

1 lb	3 lbs	6 lbs	8 lbs	11 lbs	20 lbs	49 lbs

Indiana County

Pool No. 181, Juneau. From 1887 to 1900 about 40 wells were drilled to the northwest of Juneau, some of the wells obtaining their gas supply from the "Gas" sand (Berea or Hundred Foot) and others from a deep sand thought to be the Tiona at 2700 to 2900 feet deep. Pressure in the wells varied from 40 to 425 lbs. per square inch. Several of the wells are still producing small quantities of gas.

Pool No. 182, Smicksburg. The record follows of minute pressures of a well for a 6¼ inch casing:

	1 min	2 min	3 min	4 min	5 min	10 min	15 min	20 min	30 min
12-18-18	2 lbs	4 lbs	5 lbs	7 lbs	9 lbs	19 lbs	28 lbs	37 lbs	54 lbs
1-21-19	1 lb	2 lbs	3 lbs	4 lbs	5 lbs	10 lbs	15 lbs	19 lbs	29 lbs

Indiana County, (Cont'd)

Pressure against Line Pressure:

		5 min.	10 min.	15 min.	20 min.	30 min.
3-18-19	L. P. 14 lbs	19 lbs	24 lbs	25 lbs	31 lbs	35 lbs
3-22-20	L. P. 22 lbs	26 lbs	30 lbs	33 lbs	36 lbs	40 lbs

A well in April, 1920 made 31,400 cu. ft. of gas daily with 165 lbs R. P.

Pool No. 183, Willett. In 1891 in shallow sands this pool had a rock pressure of 275 lbs and in 1901 of 100 lbs. In 1904 a well had a rock pressure of 700 lbs. In 1906 the same well recorded a pressure of 234 lbs. and flowed 126,240 cu. ft. a day. This increased in 1916 to 207,552 cu. ft. a day with a rock pressure of 550 lbs.

Pool No. 184, Creekside. A well in 1901 had a rock pressure of 325 lbs. The same well in 1917 made 1,350,000 cu. ft. of gas a day with a pressure of 120 lbs.

Pool No. 185, Strongstown. Gas was obtained from a couple of wells in this pool several years ago.

General:

In 1919 about a half dozen wells were drilled a little to the northwest of Marion Center, some of which had a rock pressure of 840 lbs. to the square inch. A well drilled in on July 8, 1919, had a rock pressure of 770 lbs with an initial flow of 1½ to 3½ million cu. ft. The rock pressure of this well had decreased to 270 lbs. by April 3, 1920, and on October 7, 1920, the rock pressure was 235 lbs, the well making 180,000 cu. ft. A deep test well is being drilled by the T. W. Phillips Oil and Gas Company near Marion Center in East Mahoning Township. Gas was encountered in August, 1920, at 5671 feet and in December, 1920, this well was drilling at 7000 feet; but on February 24, 1921, a fishing job was on hand at this depth.

Cambria County

Pool No. 186, Cherry Tree. About 1865 a well was drilled on the east bank of the Susquehanna River a few feet above the water, within the borough limits of Cherry Tree. Gas was obtained at a depth of 250 feet. The tools were lost at a depth of 652 feet and the well abandoned. For record of well and analysis of gas see page 179 Vol. HH Second Pennsylvania Geological Survey Progress Report 1875.

Pool No. 187, Carrolltown. In 1911 six wells were making 180,000 cu. ft. of gas a day at a depth of 2400 to 2700 feet, average depth 2500 feet. Four wells were producing 80,000 cu. ft. of gas a day in December 1920.

Pool No. 188, Belsano. A single well here made 15,000 cu. ft. of gas a day recently.

Washington County

Pool No. 189, Florence. Original well had a production of 100 to 500 bbls. of oil a day but it has settled to a barrel or less now. In 1918 a gas well made 100,000 cu. ft. of gas with 200 lbs. rock pressure.

Pool No. 190, Eldersville. This pool produced considerable quantities of gas. In 1920 one well produced 65,160 cu. ft. of gas a day with 510 lbs. rock pressure.

Pool No. 191, Burgettstown. This pool originally produced gas but later produced oil. A well in 1916 produced at the rate of 100 barrels a day.

Pool No. 192, McDonald. This pool is classed as one of the largest pools in southwestern Pennsylvania. The maximum daily production was reached in November 1891, namely 83,000 bbls. a day. Wells twenty-five years old are still making 8 bbls. a day. In 1892, this pool together with a few small ones, produced 8,400,000 bbls. of oil. In 1909 these same pools produced 465,000 bbls. of oil. To the middle of the year 1909, the total production of this pool was 42,135,000 barrels. No new developments for 15 years except wells to the south which were drilled about 3 years ago. The wells made from 10 to 30 bbls. a day each.

Pool No. 193, Venice. Similar conditions as in Pool No. 192. Wells perhaps are not so large. Initial production of a well in 1891 was 400 bbls. a day. The record of two wells in this pool follows:

1914	1312	bbls	1914	187	bbls
1915	1336	bbls	1915	171	bbls
1916	1243	bbls	1916	246	bbls
1917	1495	bbls	1917	186	bbls
1918	1361	bbls	1918	159	bbls
1919	605	bbls	1919	136	bbls
1920	Exhausted		One half of 1920 - 60		bbls.

Washington County (Cont'd)

Early in the year 1913 several new wells were completed in this pool ranging in initial production from 35 to 50 barrels a day.

Pool No. 194, Hickory. This pool produced enormous quantities of gas. The original well "blew wild" for more than a year before an attempt was made to utilize the gas. Recent drilling has been quite active.

Pool No. 195, Canonsburg. Most of the gas is obtained from the Hundred Foot and Fourth sands, while the oil comes mostly from the Fifth sand. Average depth of wells 2300 feet. In June of 1911 on the Stewart Park lots several wells were drilled, the largest one yielding 600 bbls. of oil a day. The pool declined very rapidly. A well in 1917 made 88,000 cu. ft. a day, and in 1920 the same well was making 67,000 cu. ft. a day. On the third of December, 1920, a two million cu. ft. gas well was reported on the W. J. Govern farm in North Strabine Township. The well was spraying some oil, all coming from the Gordon or Third sand. Another well on the McNary farm was making 2 bbls. of oil daily from the lower part of the Hundred Foot sand.

Pool No. 196, Buffalo. Exceedingly large gas pool. Production from all the principal producing sands. Original pressure of 900 lbs. in Fourth and Fifth sands. In the Hundred Foot sand the pressure was somewhat less. A well in 1916 produced 466,000 cu. ft. a day, but had a very low rock pressure.

Pool No. 197, Linden. A well in 1901 flowed at the rate of 25 bbls. an hour. In 1918 the same well made 15 bbls. a week. In 1919 it made 20 bbls. a week, but in 1920 it decreased to 12½ bbls a week.

Pool No. 198, Finleyville. Most all the sands are productive in this pool. The Dunkard sand, which is 660 feet below the Pittsburgh coal, has furnished considerable quantities of gas. On January 7, 1921, a well was reported as making 20 bbls. of oil a day. This well is the third to be drilled on the Morrison lease. At the present time No. 1 is pumping 10 bbls. of oil a day; No. 2 is making 3 bbls. a day, while No. 3 is producing two million cu. ft. of gas a day, besides its flow of oil.

Pool No. 199, Mehaffay. The original Mehaffay well reported a rock pressure of 1250 lbs. per square inch. On May 10, 1910, the pool contained 22 producing wells and 5 dry holes. In 1907 a well produced 2,200,00 cu. ft. of gas a day. This well however was abandoned in December of 1914.

Pool No. 200, Washington and Taylorstown. This pool produced during its first two years 2,418,872 bbls. of oil. Maximum daily production was reached in October of 1886, viz: 17,549 bbls. There are about 80 wells in the pool, some of which produced from 1000 to 4000 bbls. daily. A well completed in 1918 made 60 bbls. a week. The same well in 1919 made 48 bbls. a week and in 1920 had decreased to 30 bbls. a week. Another well, drilled in 1887, was making 2½ bbls. a week in 1918; in 1919 it had increased to 4 bbls. a week, and at the present time, (latter part of 1920) it is still producing. On December 17, 1920, a five barrel pumper was completed to the Fifth sand on the Clark Shrontz farm.

Pool No. 201, Lagonda. Production is from most all the known sands. The Dunkard and Salt sands have both been productive in this pool. A well in 1910 was making 173,000 cu. ft. a day with 225 lbs. rock pressure from the Thirty Foot sand. In 1919 a well from the Fifth sand was making 2,166,000 cu. ft. daily, rock pressure 420 lbs. This well is now making from 2 to 3 bbls. of oil daily. A well came in in April of 1919 producing 290 bbls. of oil a day from the Fifth sand. The average production for 1919 of this one well was 80 bbls. a day and for 1920 it was 50 bbls. a day. On February 14, 1920, a well was drilled in, making 50 bbls. of oil a day. From February 14 to March 1, this well produced 863 bbls. of oil; during the month of March, 1010 bbls; April, 610 bbls; May, 587 bbls; and June, 893 bbls. A well reported to be making from five to ten million cu. ft. of gas a day was reported on December 24, 1920. The well was drilled by the Freehold Oil and Gas Company, and is located two miles south of Washington

Washington County (Cont'd)

on the Dr. G. B. Dunkle farm. On January 12, 1921, a well was drilled to the Fifth sand and was estimated to be producing 500 bbls. of oil a day. The well is being drilled to the second pay in the Fifth sand.

Pool No. 202, Ross. A well in 1901 was making 11,340,000 cu. ft. of gas daily, which in 1919 had decreased to 95,000 cu. ft. daily and in 1920 to 67,000 cu. ft. daily.

Pool No. 203, Somerset. In 1916 a well with a rock pressure of 820 lbs. in the Hundred Foot sand made 786,000 cu. ft. of gas daily and in 1920 this same well with a rock pressure of 280 lbs. was making 155,000 cu. ft. a day. In 1918 a well came in making 9 million cu. ft. daily with 980 lbs. rock pressure. The well is still making one million cu. ft. daily with a pressure of 178 lbs. A well came in in 1915 making 4 million cu. ft. daily with 450 lbs. rock pressure, the present production of which is one half million cu. ft. daily with 95 lbs. rock pressure.

Pool No. 204, West Finley. A good supply of both oil and gas was obtained from the Big Injun, Hundred Foot, Third and Fifth sands.

Pool No. 205, Dague. The discovery well was a gas well from the Big Injun sand. The next well was a 400 bbl. oil well from the Fifth sand. Some gas was obtained from the Fourth sand, while oil came from the Gordon Stray and Gordon. A well in the Gordon Stray in 1916 had an initial production of 20 bbls. of oil a day, decreasing in 1918 to 45 bbls. a week; in 1919 to 30 bbls. a week and in 1920 to 15 bbls. a week. The Big Injun gas well was as large as 3,750,000 cu. ft. a day. In 1916 a well produced 591,000 cu. ft. of gas a day under 240 lbs. rock pressure. On March 30, 1917, a Gordon well came in making 100 bbls. of oil a day. Production has decreased each year since, as the record shows the same well made in 1918 about 75 bbls. a week, and in 1919 about 30 bbls. a week, and the average for 1920 has been about 15 bbls. a week. On September 2, 1914, a well completed to the Fifth sand came in making 5 bbls. a day. The record for 5½ years of this well shows

1915	1071 bbls	1918	240 bbls (2 wells)
1916	960 bbls	1919	1425 bbls (2 wells)
1917	1650 bbl (2 wells)	One half of 1920 - 691 bbls.	

In June of 1917 a well came in in the Fourth sand making 40 bbls. a day, which produced in June of 1918 a weekly average of 85 bbls. and in June of 1919 a weekly average of 60 bbls. In January of 1920 it had decreased to 45 bbls. a week and the following May to 38 bbls. a week.

Pool No. 206, Amity. A well in 1912 was making 2 million cu. ft. of gas a day under 620 lbs. rock pressure from the Big Injun and Hundred Foot sands. The well was drowned out May 7, 1917.

Pool No. 207, Lone Pine. In 1912 a well was producing gas from the Third sand at the rate of 1½ million cu. ft. a day. The same well is now making 42,000 cu. ft. a day with 50 lbs. rock pressure.

Pool No. 208, Daniels Run. A well in 1917 was making 1 million cu. ft. of gas a day with a rock pressure of 415 lbs. In September, 1919, with a rock pressure of 150 lbs., this same well was producing 300,000 cu. ft. of gas a day. A well in 1917 was making 345,000 cu. ft. a day from shallow sand (the First Salt sand) 900 feet below the Pittsburgh coal. This well made in 1919 a daily production of gas of 138,000 cu. ft., but was abandoned in 1920.

Pool No. 209, Zollersville. This gas pool seems to be more in the basins than along the slopes of the anticline, which is an exception to the general rule. In 1902 a well made 80,000 cu. ft. a day with a rock pressure of 200 lbs.

Pool No. 210, Bellevernon. Original well from Hundred Foot and Third sands produced from 4 to 5 million cu. ft. of gas daily with a rock pressure of 900 lbs. Many old wells pulled out. Rock pressure now is 50 lbs. to the square inch. A well drilled in January 15, 1916, made 4,633,000 cu. ft. of gas daily. In 1917 the rock pressure was 85 lbs.; in 1918 it was 53 lbs. with a production of 200,000 cu. ft. daily. In 1920 the pressure was down to 42 lbs. In 1915 a well drilled to the Payard sand (2700 feet) with a rock pressure of 615 lbs., produced a daily volume of 1,746,110 cu. ft. of gas. On January 31, 1921, a well was drilled in the Fifty Foot sand

Washington County, (Cont'd)

at 2207 feet and a flow of gas estimated from 5 to 15 million cu. ft. was made. The well caught fire and the derrick was destroyed. This well is located on the Hopkins farm in Rostraver Township, back of Monessen.

Allegheny County

Pool No. 211, Candor. A well in December, 1913, made 625,000 cu. ft. of gas a day.

Pool No. 212, McMurry. A well in 1915 from the Hundred Foot sand produced 40,000 cu. ft. of gas a day. In 1919 the same well had decreased to 30,000 cu. ft. daily, and in 1920 to 16,000 cu. ft. daily. A well in 1916 from the Hundred Foot and Fifth sands produced 216,000 cu. ft. of gas daily. In 1919 the same well dropped to 167,000 cu. ft. daily and in 1920 to 95,000 cu. ft. daily. The oil comes mostly from the lower part of the Hundred Foot sand. On January 29, 1921, a gas well was struck in Pilus Township at 1180 feet. Initial flow estimated at 1½ million cu. ft.

Pool No. 213, Carnot. No new developments for over 8 years. A well in June, 1912, made 67,400 cu. ft. of gas, a day with a rock pressure of 600 lbs. to the square inch.

Pool No. 214, Leetsdale. Oil from the Hundred Foot sand, and gas from the Fourth and Thirty Foot sands.

Pool No. 215, Moon. Oil from the Hundred Foot and gas from the Thirty Foot sands. In July of 1915 a well made 393,120 cu. ft. a day. In 1916 the same well was making 134,400 cu. ft. a day. The rock pressure was 298 lbs. to the square inch.

Pool No. 216, Coraopolis. The Third sand yields oil while the Fourth sand yields gas. Pressure in the Third sand in 1913 was 44 lbs. and in 1918 it had increased to 325 lbs. In 1916 the pressure in the Fourth sand was 130 lbs., which in 1919 decreased to 30 lbs.

Pool No. 217, Aten. Original wells (both oil and gas) are small. In 1913 the rock pressure in the Fourth sand was 350 lbs. to the square inch.

Pool No. 218, Imperial. Average daily production was 25 bbls. but is now very low. Both gas and oil from the Hundred Foot sand. In October of 1918 a well was making 116,000 cu. ft. of gas a day with 73 lbs. rock pressure.

Pool No. 219, Moon Run. The Hundred Foot and Third sands are oil bearing, while the Fourth and Fifth sands are gas bearing. A well drilled in February 3, 1899, is producing at the rate of 6.74 bbls. a day in 1920.

Pool No. 220, McCurdy. Much oil produced from 1890 to 1892 from many large wells. Oil mostly from the Fifth sand. The Hundred Foot, Third and Gordon sands have furnished considerable quantities of gas.

Pool No. 221, Brush Creek. A well in December, 1899, made 660,000 cu. ft of gas a day. In 1919 a well made 77,000 cu. ft. a day and in 1920 it had dropped to 67,000 cu. ft. a day. In 1910 a well made 570,800 cu. ft. daily, in 1919 it made 170,000 cu. ft. a day, and in 1920 had decreased to 26,000 cu. ft. a day. A 20 bbl. oil well was brought in in the summer of 1920 from the Snee sand.

Pool No. 222, Ingomar. Oil from the Hundred Foot and gas from the Third and Fourth sands.

Pool No. 223, Keown. A well drilled in February 16, 1893, produced 2,070,000 cu. ft. of gas a day. This well was abandoned in 1919.

Pool No. 224, Glenfield. Big production from the Fourth sand. Some production from the Hundred Foot and Third sands. In May, 1896, a well made 3¼ million cu. ft. of gas a day. In 1919 the same well made 160,000 cu. ft. a day and in 1920 had dropped to 67,000 cu. ft. a day.

Pool No. 225, Wildwood. A very large Third or Gordon sand pool. On January 19, 1891, the maximum output of 18,000 bbls. a day was reached. Pool almost depleted in 1911. On June 4, 1906, a well produced 7 bbls. a day. In 1917 it had dropped to 2 bbls. a day and at the present time this well is making ⅛ of a bbl. of oil a day. A well near Wildwood on the Harry Short farm in Hampton township was estimated as making 1,000 bbls. of oil a day from the Fourth sand at 1769 feet in July of 1920. Later reports say 45 bbls. a day.

Pool No. 226, Chartiers. The Third or Gordon sand yields most of the oil, while the Hundred

Allegheny County, (Cont'd)

Foot sand has produced both oil and gas. In 1907 the production was small.

Pool No. 227, Bellevue. Most of the oil was obtained from the Hundred Foot sand but wells were soon exhausted. Gas was obtained from the Third and Fifth sands. The Fourth sand in 1908 had a rock pressure of 300 lbs., which had decreased in 1919 to 82 lbs. The pressure in the Third sand in 1919 was 173 lbs. On December 13, 1898, a well made 302,400 cu. ft. of gas from the Third and Fifth sands.

Pool No. 228, Carnegie. A well in August, 1911, had a rock pressure of 730 lbs. to the square inch. In 1919 this well was making 83,000 cu. ft. of gas a day and in 1920 still flowing 67,000 cu. ft. a day. An oil well drilled in December 19, 1913, had an initial production of 11 bbls. a day but is now producing only 1.71 bbls. a day. A well near Duff City started with an initial production of 250 bbls. a day in 1913.

Pool No. 229, Lickskillet. Oil from the Hundred Foot sand and gas from the Fourth and Fifth sands. A well on October 29, 1895, made 100,000 cu. ft. of gas a day and produced until 1920, when it was exhausted. An 8 bbl. well was reported between Bridgeville and McDonald on the H. Carl farm on December 17, 1920.

Pool No. 230, Bridgeville. Small gas pool with production from all the sands. About 30 wells in original pool. In February of 1901 a well produced 1,200,000 cu. ft. of gas a day. In June of 1919 this same well was producing 170,000 cu. ft. a day and in May of 1920 it had dropped to 54,000 cu. ft. a day. In 1907 the rock pressure was 235 lbs. in the Hundred Foot and Gordon Stray sands.

Pool No. 231, Clifton. The first well in 1887 was drilled for oil but a big gas well was encountered. The gas was thought worthless and was allowed to blow open for more than a year. On April 26, 1917, a well produced 10 bbls. of oil a day from the Hundred Foot sand. During the remainder of 1917 this well gave 1101 bbls. In 1918 it made 1667 bbls.; in 1919 it made 1354 bbls., and for one-half of 1920 the record shows 622 bbls.

In 1907 the Big Injun sand had a rock pressure of 400 lbs. The record (not consecutive) of the rock pressure in several sands follows:

Hundred Foot Sand	1891	200 lbs	1908	300 lbs	1918	350 lbs
	1907	235 lbs	1915	360 lbs	1919	300 lbs
Gordon Stray sand:			1907	200 lbs	1919	186 lbs
Third or Gordon sand:			1907	200 lbs	1910	135 lbs
			1908	240 lbs	1916	265 lbs
Fifth sand:			1884	300 lbs	1914	185 lbs
			1913	420 lbs	1919	144 lbs

Pool No. 232, Deer Creek. Small oil production from the Fourth sand. A 25 bbl. well in the Fifth sand was drilled in on October 22, 1920. A 400 bbl. well was drilled in on December 26, 1919, in Harmar Township. In the latter part of 1913 near Dorseyville, a 600 bbl. well was completed to the Thirty Foot sand, which made this locality very attractive. The pay sand averages 8 feet thick.

Pool No. 233, Allison Park. This pool has been under development since 1880. Principal producing sand is the Thirty Foot; however, the Murrysville, Hundred Foot and Third sands have all produced both oil and gas. Very little drilling is being done at the present time (March, 1921). There are about 12 oil wells and 3 gas wells draining their supply from the Hundred Foot sand. The Speechley and Bradford sands have both been tested, without finding production in paying quantities.

Pool No. 234, Tarentum. A well in November, 1911, produced from the Speechley sand 318,000 cu. ft. of gas a day, and in 1920 this same well made 152,000 cu. ft. of gas a day. Another well in September, 1917, produced 765,600 cu. ft. a day which dropped in 1919 to 212,760 cu. ft. a day. This well in August of 1920 produced 75,000 cu. ft. of gas daily.

Pool No. 235, Plum Township. Gas from the Fifth, Speechley and Bradford sands and oil from the Speechley. A well completed April 5, 1913, produced 1,210,500 cu. ft. of gas daily with rock pressure of 825 lbs. to the square inch. This same well produced in 1914 a flow of 1,110,000 cu. ft. daily; 68,000 cu. ft. daily in 1815 with a rock pressure of 40 lbs., and in 1916 the well was exhausted. A well in 1918 produced 78,600 cu. ft.

Allegheny County, (Cont'd)

of gas a day, which decreased in 1919 to 26,500 cu. ft. a day and dropped in 1920 to 12,000 cu. ft. a day. A well drilled in on July 13, 1917, had an initial production of 377 bbls. of oil a day. At the present time this well is making 2.92 bbls. a day. Another well drilled in on March 28, 1918, had an initial production of 25 bbls. a day, and at the present time is producing 6.56 bbls. a day. In this pool the record of a number of wells for the past 6½ years follows:

Year	Wells	Barrels
1914	2	4,828
1915	7	18,267
1916	12	18,059
1917	17	16,653
1918	16	11,260
1919	16	9,018
1920(½)	16	3,650

In July of 1920 a well making 50 bbls. a day was drilled in on the McMahon farm in the Hundred Foot sand.

Pool No. 236, Homewood and Swissvale. Old abandoned pool. Only a few wells drilled, with small production. Gas from the Murrysville, Fifth and Speechley sands. Most of the wells were drilled by the Westinghouse Company. This pool includes the Nine Mile Run development. Three old wells were drilled from 1894 to 1895. About a half dozen wells were drilled in 1920. One well made 3 million cu. ft. of gas a day, but was soon drowned out. Some 3 or 4 wells have been drilled near Swissvale, one to the Fifth sand producing for the week of September 15 to 21st, 29,160,200 cu. ft. of gas and for the week of September 22 to 28th, 19,897,600 cu. ft. of gas and for the week of September 29 to October 6th, 18,707,400 cu. ft. of gas. Several other wells now drilling (December, 1920).

Pool No. 237, White Ash. Gas obtained from both the Fifth and Speechley sands, and oil from the upper sands. Several wells are drilling at the present time. The volume of a well on March 3, 1914, was 169,000 cu. ft. of gas a day with a rock pressure of 60 lbs. In 1916 the pressure was 30 lbs. and in 1917 dropped to 20 lbs. In 1920 it was low.

Pool No. 238, Clugston. Gas from Big Injun, Sixth and Elizabeth sands. A well on August 25, 1917, produced 225,000 cu. ft. of gas a day. In 1919 this same well produced 210,000 cu. ft. a day and in June of 1920 was still producing 48,000 cu. ft. a day. Another well drilled in on August 5, 1918, produced 126,000 cu. ft. a day, which had dropped in 1920 to 94,000 cu. ft. a day.

Pool No. 239, Homestead. A well drilled in on June 20, 1914, produced 850,000 cu. ft. of gas a day from the Hundred Foot and Third sands, with a rock pressure of 235 lbs. In 1920 the same well produced 53,000 cu. ft. daily.

Pool No. 240, Mifflin. A well in 1915 produced 168,000 cu. ft. of gas a day which in 1919 dropped to 152,000 cu. ft. and in 1920 to 50,000 cu. ft. daily.

Pool No. 241, Rodfield. A well which on March 3, 1916, produced 770,500 cu. ft. of gas a day had a daily production in 1920 of 67,000 cu. ft.

Pool No. 242, Elizabeth. Oil obtained from the Elizabeth sand about thirty years ago and gas from the upper sands. A well was completed in June of 1920 which had only 60 lbs. rock pressure. Several other wells are now drilling.

Pool No. 243, McKeesport. The main producing sand was the Speechley, although considerable quantities of gas were obtained from the upper sands. Original rock pressure of the pool was about 1400 lbs. to the square inch, the present pressure varies from a few lbs. to a 12-inch vacuum. The "Big Well" produced over 56,000,000 cu. ft. of gas in a single day (Sept. 24, 1919). The total production of the field fromAugust 23, 1919, to March 1, 1921, was over 17,173,890,000 cu. ft. About 635 wells were completed in this pool. Many other wells were promoted, abandoned or the locations abandoned before completion. All in all there were about 1,000 holes in the McKeesport gas pool. In July of 1915 a well was completed on the Spiegel farm near East McKeesport, which was estimated as making 60 million cu. ft. of gas daily. The well was exhausted in about three months. The production was from the Hundred Foot sand. Several wells have since been completed in this vicinity and nearly one million cu. ft. of gas is produced daily from this pool.

Pool No. 244, Lincoln. Located at the west extension of the McKeesport pool, with a much

Allegheny County, (Cont'd)

smaller production. A well drilled in on June 2, 1920, produced 515,000 cu. ft. of gas a day from the Elizabeth and Speechley sands. January 1, 1921, the same well dropped to 250,000 cu. ft. a day.

Pool No. 245, Forward. A well in 1912 produced from the Hundred Foot sand 8 million cu. ft. of gas a day. It was exhausted in one year. Some gas was also obtained from the Thirty Foot sand.

General:

In Harmar Township on the W. S. Carson farm the Summit Oil and Gas Company got a 10 bbl. producer from the Fifth sand. On March 22, 1920, in the same district, another well produced 25 bbls. a day.

The rock pressures of the oil and gas bearing sands in various townships follow:

Big Injun sand	Bethel Township	1917	430 lbs
Hundred Foot	Bethel, Scott, Snowden, Upper St. Clair and Baldwin Townships	1891	200 lbs
		1907	235 lbs
		1908 Bethel	300 lbs
		1915	360 lbs
		1916	80 lbs
		1917	70 lbs
	Baldwin	1918	300 lbs
		1919	88 lbs
Third or Gordon	Upper St. Clair and Aleppo Township	1907	200 lbs
		1919	180 lbs
Sixth or Bayard	Baldwin and Jefferson Townships	1914	305 lbs
Gordon Stray sand	Bethel and Upper St. Clair Townships	1907	230 lbs
		1908	240 lbs
		1910	135 lbs
		1915	265 lbs
Fifth sand	Bethel, Baldwin and Jefferson Townships	1894	300 lbs
		1913	420 lbs
		1914	185 lbs
		1919	144 lbs

Westmoreland County.

Pool No. 246, Braeburn. A well in November, 1911, produced 240,000 cu. ft. of gas a day. In 1919 the same well produced 195,000 cu. ft. of gas a day, while in June of 1920 it produced 152,000 cu. ft. a day.

Pool No. 247, Pine Run. A well in 1908 produced 134,400 cu. ft. of gas a day from the Hundred Foot sand. The same well was deepened in 1911 to the Bradford sand (3395 feet). The well then produced 95,000 cu. ft. a day with a rock pressure of 45 lbs.

Pool No. 248, Murrysville. A very large gas field. Original wells made as much as 25 million cu. ft. daily. Field developed in 1878 and gas was piped away in 1884. Original wells produced from the Murrysville sand, but the production now is also from the Speechley sand. Most all wells are now placed on vacuum. A well on January 1, 1919, produced 12 million cu. ft. of gas from the Murrysville and Sixth sands with a rock pressure of 200 lbs.

Pool No. 249, Bell Township. A well drilled in on November 17, 1916, produced 30,000 cu. ft. of gas a day. The 60 minute pressure was 300 lbs.

Pool No. 250, Saltsburg. Wells small. Gas from the Murrysville and Thirty Foot sands.

Pool No. 251, Delmont. Gas from the Fifth, Elizabeth, Speechley and Tiona sands. On December 23, 1907, from the Elizabeth sand, a well produced 9,132,000 cu. ft. of gas a day with a rock pressure of 1050 lbs. The same well in 1909 made 277,300 cu. ft. a day and in 1910 it had increased to 304,300 cu. ft. a day. A well on April 28, 1908, produced 3,852,000 cu. ft. from the Fifth sand with a rock pressure of 940 lbs. per square inch. A well on September 23, 1916, produced 263,000 cu. ft. of gas from the Speechley and Tiona sands. In 1919 the daily production of this well was 56,000 cu. ft. with a rock pressure of 247 lbs. and in 1920 with a rock pressure of 210 lbs. the production per day decreased to 32,000 cu. ft. On July 21, 1917, a well produced 303,000 cu. ft. of gas from the Bradford sand at a depth of 3700 feet.

Pool No. 252, Grapeville-Arona. A well in September, 1916, produced 260,000 cu. ft. of gas a day from the Speechley sand. Same well in 1919 produced 60,000 cu. ft. a day, and in 1920 it produced 40,000 cu. ft. a day. On July 12, 1917, a well made 303,000 cu. ft. of gas from the Bradford sand. A well near Arona came in in September of 1920, producing 5 million cu. ft. of gas a day with 1200 lbs. rock pressure from the Speechley sand at a depth of 2840 feet. Much drilling in this vicinity. Up to January 12, 1921, several wells making two million cu. ft. of gas a day were reported, two of the wells making 4 million cu. ft. each a day—one on the James McMillan farm and the other on the Joshua Miller farm. A six million cu. ft. well was reported on the Daniel Gordinan farm and a

Westmoreland County, (Cont'd)

ten million cu. ft. well on the Christopher Fink farm. Several wells are now under way and this pool promises to be a good one. No dry holes have been reported.

Pool No. 253, Latrobe. A well drilled May 24, 1909, produced 787,000 cu. ft. of gas. The 12-hour pressure was 130 lbs. This well is still producing.

Pool No. 254, Pleasant Unity. From this pool small quantities of amber oil were obtained from the Hundred Foot sand, at a depth of 1800 feet. Oil was not obtained in commercial quantities. On July 10, 1920, a well obtained a little oil at 1200 feet on the Miller farm.

Pool No. 255, McCance. One well in pool and another being drilled. Both owned by the People's Natural Gas Company. The producing sand is the Oriskany at 6800 feet. The well mouth is 1650 feet below the Pittsburgh coal horizon, therefore this Oriskany sand is 8450 feet below that horizon. The well is making 500,000 cu. ft. of gas a day.

Pool No. 256, Sutersville. Production is from the Hundred Foot sand. On March 1, 1911, a well produced 4 million cu. ft. of gas. The 5 minute pressure was 300 lbs. Record of rock pressure for 5 years was:

January	1916—160 lbs	June	1918—100 lbs
July	1916—500 lbs	June	1919—225 lbs
June	1917—110 lbs	June	1920—200 lbs

The production for 1919 averaged 45,000 cu. ft. a day and for 1920 it had decreased to 23,000 cu. ft. a day. There is considerable drilling at the present time.

Pool No. 257, West Newton. The producing sands are the Big Injun and the Hundred Foot. The record for a well for eight years drilled in to the Big Injun sand on September 29, 1911, follows:

1911	6,500,000 cu. ft. daily	R. P. 810 lbs
1913	6,350,000 cu. ft. daily	R. P. 700 lbs
1914	5,750,000 cu. ft. daily	R. P. 665 lbs
1915		R. P. 670 lbs
1916		R. P. 650 lbs
1917		R. P. 585 lbs
1918 (Nov)	5,527,000 cu. ft. daily	R. P. 575 lbs
1920 (July)	221,000 cu. ft. daily	R. P. 375 lbs

Several wells were drilled along Pollock Run just west of West Newton in June, 1920, to the Big Injun sand. Early wells produced one million cu. ft. of gas a day but were soon drowned out. Many of the wells were drilled to the Speechley sand. No increase in production.

Pool No. 258, Webster. Original wells drilled to the Hundred Foot and Third sands, produced from four to five million cu. ft. daily with a rock pressure of 900 lbs. The present rock pressure is 50 lbs.

Greene County

Pool No. 259, Fonner. Oil and gas from the Hundred Foot sand, also oil from the Fourth sand. Some gas from the Big Injun sand. Original wells made as high as 800 bbls of oil a day. Many of the old wells are now abandoned. On August 30, 1915, a well was drilled in making 2 bbls. a day from the Fourth sand.

Year	Bbls.
1915 (4 mos.)	155
1916	294
1917	208
1918	196
1919	193
1920 (6 mos.)	87

A well in the Hundred Foot sand drilled in on November 6, 1919, had an initial production of 100 bbls a day. From November 22 to 29 the week's production was 560 bbls., and for the month of December it was 1987. For seven months in 1920 the record shows:

January	2147	barrels	April	1304	barrels
February	1631	barrels	May	1252	barrels
March	1447	barrels	June	1162	barrels
			July	1170	barrels

A gas well in the Big Injun sand on September 15, 1917 produced 2 million cu. ft. of gas a day with a rock pressure of 680 lbs. The present production is small from this well. The best oil well of the year (1920) was the Myers, Long and Company well named Elizabeth Meeks No. 2, which was drilled in on October 19th. This well produced from October 19th to December 19th 30,000 bbls of oil, the "big day" production being 1600 bbls. On Nov. 27th it produced 385 bbls. and on December 15th it had decreased to 300 bbls. A southern extension of the Fonner field was made in July of 1920 when the William Meeks No. 1, was completed, which produced 135 bbls of oil a day. Since the big well was

Greene County, (Cont'd)

drilled in, several others have been completed in that locality but all are light producers. Another well, the William Meeks No. 3, reported as making 100 bbls. of oil a day, came in January 6, 1921. The Myers and Long No. 1 well is still producing 25 bbls of oil daily and the No. 2 well is making about 100 bbls. a day. On January 22, 1921, a four million cu. ft. well was brought in near West Union, the production coming from the Fifth sand. At this time the big well, the Meeks No. 2, was producing about 170 bbls. daily. On January 25, 1921, the Meeks No. 2 stopped flowing and remained dry for a few days, but "came back" with 150 bbls. daily. On February 17, 1921, several wells were completed around the "big well", but as a rule they have been more or less of a disappointment. As late as the 26th of February 1921, the Meeks No. 2 well was reported as making 160 bbls. a day.

Pool No. 260, Aleppo. A well drilled in on June 11, 1910, produced ten million cu. ft. of gas a day from the Gordon Stray sand with a rock pressure of 700 lbs. The present production is 500,000 cu. ft. a day with a pressure of 190 lbs. On April 9, 1914, a well in the Hundred Foot sand produced 800,000 cu. ft. of gas a day with a rock pressure of 490 lbs. Present production (1920) 380,000 cu. ft. a day with a rock pressure of 225 lbs. A well in the Gordon Stray sand on April 16, 1916, produced 3½ million cu. ft. a day with a rock pressure of 400 lbs. The production of this well in 1920 was 400,000 cu. ft. a day with a rock pressure of 320 lbs. Several 10 to 25 barrel pumpers are being completed from time to time, and are attracting consderable attention. (December, 1920.)

Pool No. 261, Bristoria. A well drilled 3400 feet deep to the Third sand on May 13, 1901, came in flowing 20 bbls. an hour, but the well was exhausted in two years. A well in the Gordon Stray sand drilled May 20, 1907, produced 3 million cu. ft. of gas a day. In 1919 the same well was making daily 48,000 cu. ft. and in 1920 about 20,000 cu. ft. a day. On April 9, 1920, a 10 bbl. pumper was obtained from the Gordon Stray sand at a depth of 2950 feet on the Boyle farm. In November of 1920 a 225 bbl. well was obtained from the Maxon sand. On January 25, 1921, a well completed on the John P. Hampson farm came in making 300 bbls. of oil a day. While this well is in the wildcat territory, it appears to be an extension of the Bristoria pool to the northeast. On February 20, 1921, the well was reported as making 100 bbls. of oil a day. On February 3, 1921, a well was completed in the George Masters farm about seven miles west of the John P. Hampson well and was reported as making 250 bbls. of oil a day, and on March 3rd this same well was reported as making 175 bbls. a day.

Pool No. 262, Broad Tree. Oil from the Big Injun, Third and Fifth sands. A well has been producing oil for 22 years from the Big Injun sand. A well drilled in this sand in 1918 had an initial production of 165 bbls. a day and is now making 8 bbls. a day. A well in the Third sand drilled in on September 11, 1918, produced 75 bbls. of oil a day. The record of three wells since 1918 shows:

1918	3 wells produced	13,146 bbls.	
1919	3 wells produced	6,639 bbls.	
1920	3 wells produced	1,547 bbls.	for one-half the year

Pool No. 263, New Freeport. Gas from all sands. Original wells made as high as 11 million cu. ft. of gas a day from the Big Injun sand. Now producing 200,000 cu. ft. a day. A well on July 27, 1903, from the Big Injun and Third sands, produced 1,100,000 cu. ft. of gas a day. In 1920 this well was making 186,000 cu. ft. a day. Recent drilling (July, 1920) obtained gas from the Fifth sand.

Pool No. 264, Woodruff. A well drilled October 10, 1905, produced from the Big Injun sand 13½ million cu. ft. of gas a day, with a rock pressure of 1150 lbs. This well is still producing small quantities of gas. A well from the Hundred Foot and Third sands on January 23, 1911, produced 3 million cu. ft. of gas a day with a rock pressure of 300 lbs.

Pool No. 265, Lantz. Production from the Big Injun sand. Original well produced 7 million cu. ft. a day (1890) with a rock pressure of 550 lbs. It was exhausted in 1905. On January 14, 1913, a well from the Bayard sand produced

Greene County, (Cont'd)

500,000 cu. ft. of gas a day. The flow per day in 1919 was 213,000 cu. ft. and in 1920 it had decreased to 187,000 cu. ft.

Pool No. 266, Waynesburg. A well in 1896 produced from the Sixth sand 10 million cu. ft. of gas a day with a rock pressure of 900 lbs. This well is still making 100,000 cu. ft. of gas a day. In 1916 a well made 724,000 cu. ft. a day from the Big Injun and Sixth sands. At the present time (1920) it is producing 210,000 cu. ft. a day. A well in the Hundred Foot sand drilled October 29, 1898, produced 825,000 cu. ft. of gas a day. In 1920 this well had decreased to 95,000 cu. ft. a day. At present time (December, 1920) there is much drilling in this vicinity. In November of 1907 a 50 million cu. ft. gas well was completed on the Samuel Hoge farm in Center Township. The gas was under about 1000 lbs. rock pressure. Depth of well 2870 feet and gas at 2860. Another well six miles from Waynesburg had an initial production of 18 million cu. ft. of gas a day.

Pool No. 267, Gump. A well in the Sixth sand produced 250,000 cu. ft. of gas a day in 1912. The present production of this well (October, 1920) is 67,000 cu. ft. a day. Oil and gas are both obtained from the Fifth sand. In 1902 the rock pressure was 920 lbs.

Pool No. 268, Carmichaels. Production from the Big Injun, Hundred Foot, Fifth, Sixth and Elizabeth sands. On January 12, 1916, a well from the Big Injun and Fifth sands produced 2 million cu. ft. of gas a day with a rock pressure of 640 lbs. In December of 1916 the well began to flow oil and spout gas, the well producing about 50 bbls. of oil per month. In 1919 the daily volume of gas produced from this well was 308,400 cu. ft. A well in the Hundred Foot sand on May 13, 1916, produced 2½ million cu. ft. of gas with a rock pressure of 635 lbs. In 1917 the rock pressure was 505 lbs. The production record of this well for the last three years shows.

1918	586,000 cu. ft. a day	R. P.	
1919	356,000 cu. ft. a day	R. P.	390 lbs.
1920	229,000 cu. ft. a day	R. P.	370 lbs.

Pool No. 269, Garrison. Production from the Dunkard sand. Small wells but still producing. April 22, 1920, an 8 bbl. pumper was drilled in on the Cregg farm. Also from the Dunkard sand.

Pool No. 270, Mt. Morris. Oil from the Big Injun sand. Original wells produced 200 bbls a day, some of which are now producing 2 bbls a day. Gas from the Sixth sand. Wells 25 years ago made 5 to 6 million cu. ft. of gas daily. All wells are small, now running about 10,000 cu. ft. per well a day. First development began prior to 1876. Second development began 1886.

Pool No. 271, Blackshire. Oil from Big Injun sand, gas from Hundred Foot sand. A well came in on August 24, 1895, making 1,827,000 cu. ft. of gas a day.

Pool No. 272, Richhill. Gas from Thirty Foot and Third sands. Wells in 1890 produced from 5 to 6 million cu. ft. a day with a rock pressure of 850 lbs. Present rock pressure is 80 to 100 lbs. Oil is from the Thirty foot sand. Original production was 25 to 30 bbls. Present (1920) production is 4 to 5 bbls. daily.

Pool No. 273, Gray Fork. On October 13, 1914, a well produced from the Hundred Foot and Fourth sands, 3 million cu. ft. of gas a day with a rock pressure of 770 lbs.

General.

Record of rock pressures in the various sands and townships covering the last 20 years:

Big Injun Sand:

	Wayne	Franklin	Center
1903	550 lbs.		
1904	460 lbs.		
1905	450 lbs.	345 lbs.	700 lbs.
1914			95 lbs.

	Washington	Whiteley	Gilmore	Jackson
1902	520 lbs.			
1903			500 lbs.	
1914	640 lbs.	315 lbs.		
1915			100 lbs.	
1916				425 lbs.
1919	75 lbs.			37 lbs.

Greene County, (Cont'd)

Thirty Foot sand:

	Jack on
1915	250 lbs.
1919	135 lbs.

Gordon Stray sand:

	Jackson	Center
1909		910 lbs.
1917	230 lbs.	

Hundred Foot sand (Fifty Foot):

	Jack on	Center	Washington	Franklin
1903			275 lbs.	
1909		830 lbs.		
1912				
1914			725 lbs.	510 lbs.
1915	125 lbs.			
1916		675 lbs.		
1917		245 lbs.		
1918			91 lbs.	
1919			81 lbs.	

Third or Gordon sand:

	Jackson	Center	Franklin	Wayne
1902				610 lbs.
1905			1200 lbs.	
1907		400 lbs.		
1908		365 lbs.		
1909		430 lbs.		
1910		300 lbs.		
1911		300 lbs.		
1912		585 lbs.		
1913		200 lbs.		
1916	270 lbs.		250 lbs.	
1917	275 lbs.	340 lbs.		
1918	215 lbs.			

Fourth sand:

	Whiteley	Gilmore	Wayne	Jack on
1903			360 lbs.	
1905				
1913		420 lbs.		
1915	60 lbs.			420 lbs.
1919			68 lbs.	

Fifth sand:

	Center	Franklin	Gilmore	Washington	Wayne	Whiteley
1900					320 lbs.	
1901		120 lbs.				
1902			580 lbs.	1150 lbs.	600 lbs.	220 lbs.
1903					630 lbs.	
1905					275 lbs.	
1908					268 lbs.	
1909						640 lbs.
1911	430 lbs.					
1913		130 lbs.				
1917		200 lbs.				
1919		95 lbs.			55 lbs.	56 lbs.

Sixth or Bayard Sand:

	Whiteley	Center	Franklin	Wayne
1901			750 lbs	
1902				920 lbs
1904			201 lbs	375 lbs
1907		855 lbs		
1912		705 lbs		
1913	220 lbs			
1914			216 lb	
1916			740 lbs	
1918	220 lbs			
1919	82 lbs		58 lbs	

Fayette County

Pool No. 274, Luzerne. Wells drilled in 1907 made from 2 to 3 million cu. ft. of gas a day from the Hundred Foot sand with a rock pressure of 400 lbs. The wells were of short life and were exhausted in 1914. A well drilled into the Big Injun sand on August 27, 1917, produced 1,574,000 cu. ft. of gas a day with a rock pressure of 678 lbs. The record of this well for three years shows:

January	1918	1,400,000 cu ft a day	R. P. 710 lbs
November	1919	283,000 cu ft a day	R. P. 132 lbs
April	1920	63,000 cu ft a day	

Pool No. 275, Antrim Run. A well was drilled in on May 28, 1907, to the Hundred Foot sand producing 12 million cu. ft. a day with a rock pressure of 640 lbs. The record of this well for five years shows:

	1913	547,000 cu ft a day	R. P. 54 lbs
	1917		R. P. 51 lbs
June	1918	14,000 cu ft a day	
	1919	27,000 cu ft a day	R. P. 46 lbs
	1920	54,000 cu ft a day	

Pool No. 276, Waltersburg. On June 15, 1915, a well was drilled into the Big Injun sand at a depth of 1125 feet which produced 2 million cu. ft. of gas a day with a rock pressure of 350 lbs. The rock pressure of this well for the last five years as of record shows:

1916		R. P. 500 lbs
1917		R. P. 130 lbs
1918	1,000,000 cu ft a day	R. P. 130 lbs
1919	105,000 cu ft a day	R. P. 120 lbs
1920	672,000 cu ft a day	R. P. 200 lbs

A well drilled in on June 26, 1916, to the Elizabeth sand, produced small quantities of gas. The rock pressure in 1919 was 260 lbs and in 1920 it had increased to 280 lbs with a flow of 162,000 cu. ft. a day. On December 16, 1920, a four million cu. ft. gas well was reported on the

Fayette County (Cont'd)

George Work farm near Upper Middletown. This well was drilled by the Greensboro Gas Company.

Pool No. 277, Haddonville. In June of 1920 a two million cu. ft. gas well was reported from the Big Injun sand at a depth of 1300 feet.

Pool No. 278, Masontown. Production in this pool is from the Big Injun and Hundred Foot sands. The record of one well for five years shows:

March 9, 1910	1,000,000 cu ft a day	R. P. 960 lbs
1911		R. P. 240 lbs
1913		R. P. 200 lbs
1915		R. P. 90 lbs
1917	Well abandoned.	

In 1920 oil was encountered in the Dunkard sand at a depth of 900 feet. Flow is estimated at 5 bbls. a day.

Pool No. 279, Fayette. Original well very large, drilled in 1887. This supplied Uniontown for some time. Gas obtained from the Big Injun sand. Many smaller wells drilled. On February 21, 1921, it was reported that an oil well was drilled in estimated to make from 20 to 25 bbls. a day. Three producing oil wells are reported near Messmore.

Pool No. 280, New Geneva. On April 4, 1901, a well produced from the Big Injun sand 4,144,000 cu. ft. of gas with a rock pressure of 585 lbs. Rock pressure of this well for a number of years shows:

1907	R. P. 55 lbs	
1908	R. P. 55 lbs	
1909	R. P. 40 lbs	
1910	R. P. 55 lbs	
1912	R. P. 30 lbs	
1913	R. P. 55 lbs	
1914	R. P. 60 lbs	
1915	R. P. 55 lbs	
1916	R. P. 40 lbs	
1917	R. P. 38 lbs	
1918	R. P. 38 lbs	140,000 cu ft a day
1919	R. P. 38 lbs	75,000 cu ft a day

General:

On January 13, 1921 a well was reported as making 200,000 cu. ft. of gas from the Bradford sand at a depth of 3630 feet. This well is located in Lower Tyrone Township, near Dawson.

REFERENCES

Data on the oil and gas fields of Pennsylvania consist of three classes of publications:

(1) The reports of the Second Geological Survey. The oil and gas fields were described in six special volumes, entitled I, II, III, I4, I5, and J. Much additional information is given in the several reports on the counties containing oil and gas. See volume L for Pittsburgh gas well; Q, QQ, QQQ, Q4, for Beaver, Lawrence, Mercer, Crawford, Erie and south Butler counties; K for Greene County; R, R, for McKean, Elk and Forest counties; V, VV, for north Butler and Clarion counties; HH, and H7, for Cambria and Clearfield counties. Later information was given in the Annual Report for 1885 and in Part II of the Annual Report for 1886.

These reports have long been out of print. They can be consulted in many libraries in the State, or in the Library of the Engineering Societies, 29 West 39th St., New York City, or they may be purchased of second hand book dealers.

(2) Beginning in 1899 detailed surveys were started by the State under the "Topographic and Geologic Survey Commission", in cooperation with the U. S. Geological Survey. The surveys were made by the latter organization, which also published the reports. These were of two kinds: folios ($21\frac{1}{2}''$ x $18\frac{1}{2}''$), and octavo bulletins. The folios are to be obtained by writing: The Director, U. S. Geological Survey, Washington, D. C., for five cents each; except the Barnesboro-Patton, of which the cost is twenty-five cents. Many of these folios are out of print and must be sought in the libraries. The following figure shows their location with reference to county lines, the names and number and also whether available or not.

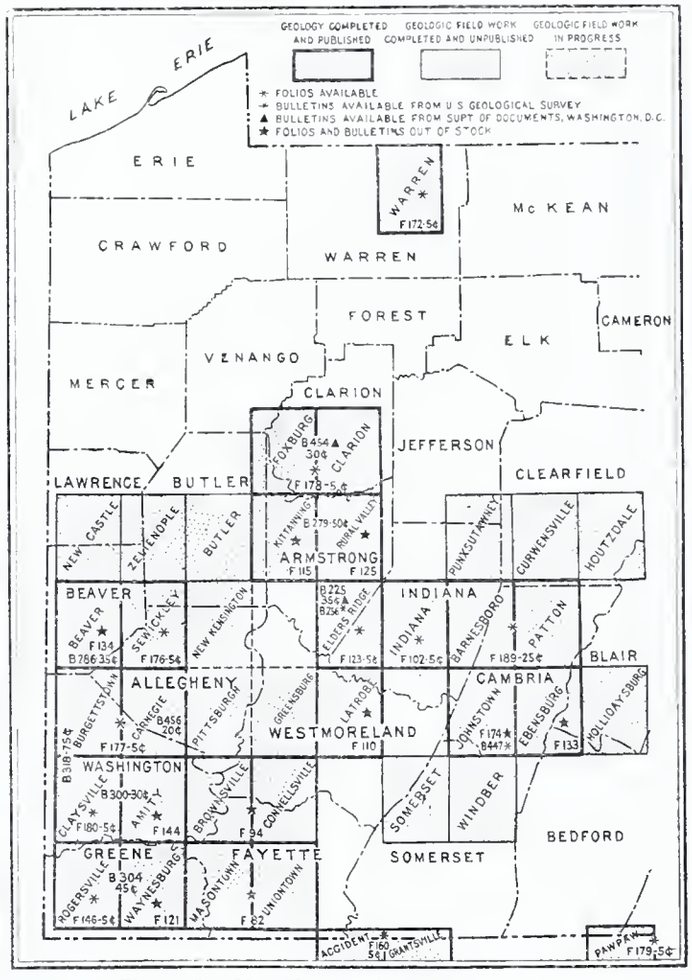


Figure 9. Map showing location of quadrangles.

Bulletins, describing the oil and gas in more detail than was done in the folios, were issued for several of the quadrangles. Most of these are out of print but can still be obtained from the Superintendent of Documents, Washington, D. C., at the prices named. (Checks or postage stamps will not be received in payment by either federal organization).

Two of these bulletins were published by the State. They covered the Sewickley and Clarion quadrangles. Both are out of print but copies will be loaned to responsible persons from the loan library of this Survey.

(3) Hundreds if not thousands of articles have been written describing the origin, geology, development or production of the Pennsylvania and other oil and gas fields. These are scattered through the proceedings of scientific societies, scientific and technical journals, and elsewhere. To have listed them would have doubled the size of this report and much delayed its publication. The more recent of these articles are listed by years in a series of bulletins entitled "Bibliography of petroleum and other allied substances for "(year)", issued by the U. S. Bureau of Mines. Many of the earlier papers are listed in a series of yearly bulletins issued by the U. S. Geological Survey entitled: "Bibliography of North American Geology for "(year)". These, so far as in stock, can be obtained by requests directed to the directors of the respective organizations named.

INDEX

Page.

Accumulation of oil and gas 8
Acres per well 31
Age of oil and gas sands 16, 22, 23, 41
Air, compressed 33
Aleppo pool 69
Allegheny County pools 64, 65, 66
  key rocks 24
  large wells 38
Allegheny Front 11, 42
  antieline 24
  depth of Trenton limestone 21
Allison Park pool 65
Ames limestone, key rock 24
Amity pool 63
Analysis of natural gas 8
Animal remains 8, 9, 41
Anthraeite fields 11
  thickness of formation 14
Anticlines 13
  not regular 39
  Forest, Elk, and Jefferson counties 39
Anticlinal theory, development of 12
Antielines, map showing asymmetry 15
Antrim Run pool 71
Apollo pool 59
Armstrong County pools 58, 59, 60
Asphaltie base 9, 10
Aten pool 64
Atlantie pool 50
Atwood pool 59
Bakerstown pool 56
Balltown pool 52
Beall pool 56
Bear Creek pool 52
Beaver County. oil shale 10
Beaver County pools 53, 54
Beaver River, folding along 12
Bellevernon pool 63
Bellevue pool 65
Bell Township pool 67
Belsano pool 61
Berea sand 11
  thickness in Northwestern Pennsylvania 34
  under Chestnut Ridge 39
Bessemer pool 53
Betula pool 49
Big Injun sand 11
Bittenbender pool 57
Blaek Hill pool 51
Blaek shales, origin 9
  oil content 10
  Central Pennsylvania 41
Blaekshire pool 70
Blair pool 57
Boyle's law 28
Bradford, increased recovery at 33
  developed at 42
  result of drilling 26
Bradford field, opening of, ... 35, 43
  produetion 46
  rejuvenation of 36
Bradford pool 49
Bradford sand, less persistent 38
Bradys Run pool 53
Braeburn pool 67
Bridgeville pool 65
Bristoria pool 69
Broad Tree pool 69

Page.

Brookville pool 60
Brush Creek pool 64
Buffalo pool 62
Bullion pool 50
Burgettstown pool 61
Butler Cross Belt pool 55
Butler County pools 54, 55, 56
Butler pool 54
California, asphaltic base 10
  Cretaeeous 10
  oil distillates 8
  oil production 46
  speeific gravity of oil 8
Callery pool 55
Cambria County pools 61
  smokeless coals 12
Cambrian, non-oil bearing 10
Camp Run pool 53
Candor pool 64
Canonsburg pool 62
Capaeity of well, how measured 28
Capillary attraetion 10
Carboniferous black shale 9
Carmiehaels pool 70
Carnegie pool 65
Carnot pool 64
Carrolltown pool 61
Carvin pool 55
Cassam Brook, gas wells 41
Catfish Run pool 57
Central Pennsylvania, outlook for oil and gas in 41
Chartiers pool 64
Cherry Grove pool 48
Cherry Run pool 57
Cherry Tree pool 61
Chestnut Ridge 9, 13, 24
  depth to Trenton limestone 21
  gas on antieline 39
  strueture west of 25
Chronology 42, 43
Clarendon pool 48
Clarington pool 52
Clarion County pools 56, 57, 58
Clarion pool 57
Cleaning wells, methods of 32, 33
Clearfield County, oil shale 10
  smokeless eoals 12
Cleveland field (Ohio), curves available 32
  overdrilled 27
  produetion of wells at 29
Clifton pool 65
Clinton County pools 52, 53
Clinton Township pool 56
Clintonville pool 55
Clugston pool 66
Coal, eharaeter, related to folding 12
  gas in 12
  relation to oil and gas 12
Colegrove pool 49
Composition of oil and gas 8
Coneord pool 55
Consumption of gas in Pennsylvania 45
Contours, explained 13, 14
  how obtained 24
Cookson pool 54
Coraopolis pool 64
Cornplanter pool 48
Coudersport pool 49

Page.

Cowanshannock pool 59
Cranberry pool 51
Creekside pool 61
Crawford County pools 50
  depth of Medina sand 34
  lack of oil in 34
Cretaceous rocks 10
Criders pool 55
Crooked Run pool 56
Crows Run pool 54
Cumberland Valley, condition of rock 41
  oil seepages 41
  rocks underlying 11
Dague pool 63
Daniels Run pool 63
Decline of oil well, cause 11
  of production 35
Deepest wells 44
Deer Creek pool 65
Delmont pool 67
Dennis Run pool 48
Depth of sands 22, 23, 47
Devonian black shales 9
Dewdrop pool 48
Diatoms 9
Discovery of oil 33
Distillates from oil and gas 8
Distillation, limits 10
  partial 9
Distribution of oil and gas 11, 34
Drake well 43, 45
  sand in 21
Dry holes, percentage of 26, 35
Economy pool 54
Eldersville pool 61
Electric heaters 33
Elizabeth pool 66
Elk County pools 52
  future gas supply 39
Elk City pool 57
Emlenton pool 51
Endeavor pool 52
Enon Valley pool 53
Enterprise pool 48
Erie County pool 47
  depth of Medina sand 34
  lack of oil in 34
Estimation of reserves 32
Evans City pool 55
Exhaustion, of oil 11
  of pressure 11
Fagundus pool 48
Fayette anticline, depth to Medina sand 39
  depth to Oriskany sand 38
Fayette County pools 71
  depth to Oriskany sand 38
  elevation of Pittsburgh coal 24
Fayette pool 72
Fiddlers Run pool 57
Finleyville pool 62
Fixed carbon in coal 12
Flooding 33
Florence pool 61
Folding, relation to oil and gas 11, 12
Folding, asymmetrical 15
  direction of 13
Fonner pool 68
Ford City pool 59
Forest County pools 51, 52
  future source in 39
Forward pool 67
Fosters pool 50
Franklin pool 51
Freeport pool 58
French Corner pool 58
Frogtown pool 57
Fryburg pool 57
Fuel ratios of coal, map showing 40

Page.

Gaines pool, ... 49
Garrison pool 70
Gas, end of 38
  future supply 37
  origin 8, 9
  production 38
  relation to structure 14
Gas belt, position of 39
Gas fields, relation to fuel ratio of coal 40
Gasolene 8
Geneva pool 50
Gilbert Run pool 49
Girty pool 59
Glade pool 54
Glade Mills pool 55
Glade Run pool 48
Glenfield pool 64
Glenhazel pool 52
Gohecnville pool 59
Goliza pool 51
Grain of rock 10, 16
  effect on flow 32
Grand Valley pool 48
Grapeville anticline, depth to Oriskany sand 38
Grapeville-Arona pool 67
Gray Fork pool 70
Greene County pools 68, 69, 70, 71
  early development 43
  production prominent 35
Greenville pool (Clarion County) 57
Greenville pool (Mercer County) 50
Gump pool 70
Haddonville pool 71
Hallton pool 52
Hanmersley Fork pool 52
Harrisville pool 54
Haymaker well 43
Hazelhurst pool 49
Heat, effect of 10, 12
  sources 9
Heaters, electric 33
Hickory pool 62
Hookstown pool 53
Homestead pool 66
Homewood and Swissvale pool 66
Howe pool 60
Igneous rock 10
Illinois, oil distillates 8
  specific gravity of oil 8
Imperial pool 64
Indiana County pools 60, 61
Ingomar pool 64
Initial production 27
  decline of 35, 42
Jefferson County pools 60
Johnetta pool 59
Juneau pool 60
Kane pool 49
Kansas oil pools 12
Kennerdell pool 50
Keown pool 64
Kerogen 9
Kerosene 8, 41
Kiefer pool 57
Knoxville pool 50
Kossuth pool 56
Kushequa pool 49
Lafayette pool 48
Lagonda pool 62
Lake Creek pool 50
Lantz pool 69
Latrobe pool 68
Laurel Ridge 9, 13
  anticline 24
  gas on anticline 39
Lawrence County pools 53
Lebanon Valley, oil seepages 41
  rocks underlying 41

Page.

Leechburg pool 59
Leeper pool 57
Leetsdale pool 64
Liekskillet pool 65
Life of wells, limited 25, 27
of gas wells 37
shown by curves 28
Ligonier well, depth of 43
Medina sand in 38
Oriskany sand in 38
Limestone Run pool 58
Limits of oil field 34
Lincoln pool 66
Linden pool 62
Little Mud Lick Creek pool 59
Lone Pine pool 63
Lubrieating distillates 8
Lueinda pool 57
Luzerne pool 71
Lyeoming County, Ramsey well 41
MeCance pool 68
MeCanee well 21
MeCrea Furnace pool 59
MeCurdy pool 64
MeDonald field, large wells 35
opened 43
production 46
MeDonald pool 61
MeDonald well 16
depth to Trenton limestone 21
Medina sand in 38
Oriskany sand dry 38
MeKean County pools 48, 49
McKeesport pool 15, 16, 28, 29, 31, 32, 37, 38, 39, 44, 66
MeMurry pool 64
Madison pool 59
Mahoning Furnaee pool 59
Manor pool 57
Marienville pool 52
Mars pool 55
Marvindale pool 49
Masontown pool 71
Maueh Chunk shale, thickness 14, 15
Medina sand, future souree of gas 42
in Erie County 34
in Ligonier well 38
in MeDonald well 38
in MeKeesport pool 39
in Ohio 34, 38
Mehaffay pool 62
Mehoopany Creek, gas wells 41
Mereer County, lack of oil in 34
Mercer pool 50
Metamorphic rocks 10
Mifflin pool 66
Mill Creek pool (Clarion County) 57
Mill Creek pool (Elk County) 52
Millstone pool 60
Miola pool 57
Monaea pool 54
Moon pool 64
Moon Run pool 64
Mt. Jaekson pool 53
Mt. Morris pool 70
Muddy Creek pool 54
Murrysville antiel'ne, depth to Oriskany sand 38
Murrysville pool 67
Names of sands 22, 23
Nansen pool 52
Naptha 8
New Bethlehem pool 58
New Castle pool 53
New Freeport pool 69
New Galillee pool 53
New Geneva pool 72
New Salem pool 59
New Sheffield pool 53
Nine Mile Hollow, wells in 38

Page.

North Buffalo pool 58
North Point pool 69
North Warren pool 48
North Washington pool 55
Number of wells in Pennsylvania 27, 35
Oeeurrence of oil and gas 10, 11
below coal measures 14
relation to structure 14
Ohio, depth of Trenton limestone 21
oil distillates 8
speeific gravity of oil 8
Oil, origin 8, 9
outlook for 33
produetion of 33, 37, 45
relation to structure 14
Oil City pool 50
Oil Creek 43
Oil fields, limits of 34
relation to fuel ratio of coal 40
Oil shales 9
Oklahoma, oil distillates 8
oil produetion 46
specifie gravity of oil 8
suecess in drilling 12
Oliveburg pool 69
Oleopolis pool 51
Oneida pool 56
Origin of oil and gas 8, 9
Oriskany sand, gas-bearing 38, 42
Ormsby pool 49
Osmosis 13
Outlook, for gas 37, 42
for oil 33
for new pools 39
in eentral and southeastern counties 41
in deeper sands 38
in eastern part of soft eoal field 39
in northeastern eounties 41
Paraffin, origin of 9
removal of 32
sealing by 11, 32, 36
Pennsylvania oil produetion 45, 46
Peters pool 55
Petrolia pool 55
Pine Grove pool 57
Pine Run pool 57
Piollett pool 57
Pithole pool 51
Pittsburgh eoal, elevation of 24, 25
Plant remains 8, 9, 41
Pleasant Unity pool 68
Pleasantville pool 50
Plum Creek pool 59
Plum Township pool 65
Pocono formation, thickness 14, 15
Pools Nos. 4 to 17 48
18 to 33 49
34 to 50 50
51 to 61 51
62 to 76 52
77 to 89 53
90 to 100 54
101 to 115 55
116 to 125 56
126 to 146 57
147 to 154 58
155 to 173 59
174 to 182 60
183 to 193 61
194 to 201 62
202 to 210 63
211 to 226 64
227 to 235 65
236 to 244 66
245 to 252 67
253 to 259 68
260 to 265 69
266 to 273 70

Page.

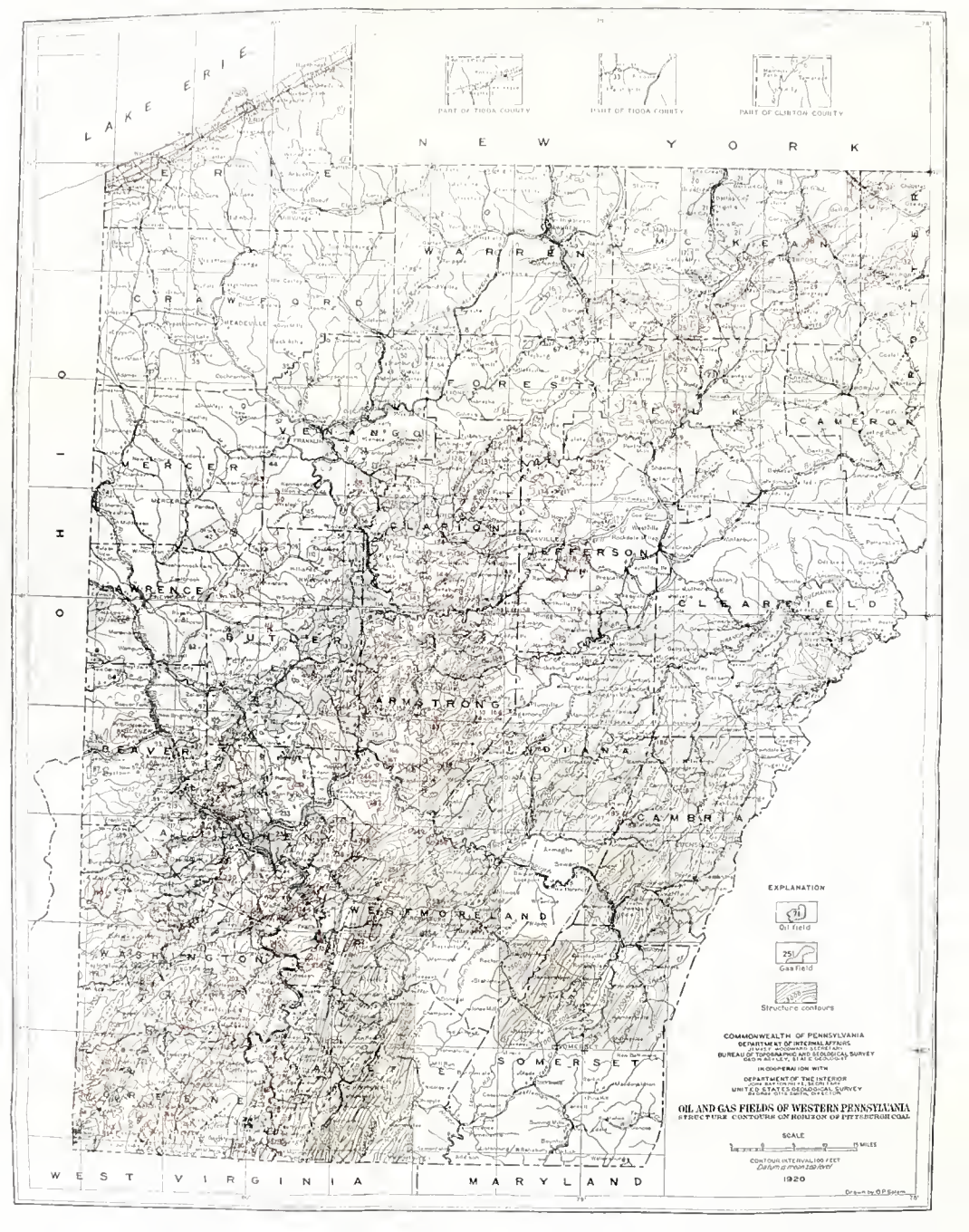
274 to 278 71
279 to 280 72
Potter County pools 49
Pottsville formation, thickness 14, 15
Pressure, necessary 10
restoration of 33
rock, decline of 30
rock, defined 27
sources 9
Princeton pool 53
Production, by years 35, 46
end of 36, 37
per well 27
Production of gas 42, 45
Production of oil, future 37
total 37, 45
Productive wells, proportion of 26
Prospective areas 39
Publications 72, 73
Ramsey pool 55
Ramsey, well near 41
Raymilton pool 50
Red beds lack oil 9, 41, 42
Rejuvenation of old fields 36
Reserves of gas, how calculated 29, 32
Reserves left after pumping 32
Ridgway pool 52
Rimersburg pool 57
Richhill pool 70
Roaring Run pool 59
Rock pressure, decline of 30, 42
defined 27, 28
Rockville pool 59
Rodfield pool 66
Rosenberg pool 55
Ross pool 63
Saekett pool 52
St. Marys pool 52
Salamanca sand in Northwestern Pennsylvania 34
Saltsburg pool 67
Salt water 13
Sandy Creek pool 51
Sands, age 16, 22, 23, 41
character 16
names 21, 22, 23
Saxonburg pool 56
Say pool 59
Seaton Creek pool 55
Separation of crystalloids and colloids 13
Shamburg pool (Clarion County) 57
Shamburg pool (Venango County) 59
Shannondale pool 58
Shannopin pool 53
Sharon pool 50
Sharps Pond, gas wells 41
Sheffield pool 48
Shellhammer pool 59
Sherrett pool 58
Shinglehouse pool 49
Sigel pool 60
Silurian rocks 16
Slate Lick pool 58
Sligo pool 57
Slippery Rock pool 53
Smethport pool 49
Smicksburg pool 60
Smith-Dunn process 33, 36
Smiths Ferry pool 53
Smokeless coal, Cambria County 12
Clearfield County 12
Snake Hollow, wells in 38
Somerset pool 63
Southeastern district 9, 11
outlook for oil and gas in 41
Spacing of wells 31
Specific gravity of oil 8
separation by 13
Speechley sand, at McKeesport 38

Page.

in Butler County 43
under Chestnut Ridge 39
Spores 9
Springs, gas and oil 11, 41, 43
Strongstown pool 61
Structure, contours explained 7, 13, 24
effect of unconformity 15
irregularities of 14, 24
of rocks 13, 24
Sugar Creek pool 51
Sugar Run pool 49
Summit pool 56
Susquehanna County, gas wells 41
Sutersville pool 68
Syncline, major 25
Synclines 13
map showing asymmetry 15
Tarentum pool 65
Thickness of formation 14
Thinning of strata 16, 21
Third oil sand in Northwest Pennsylvania 34
Thorn Creek pool 54
Tidioute pool 48
Tioga County pools 49, 50
Tionesta pool 52
Titusville, discovery at 33
Titusville pool 50
Treasury Department, method of estimating reserves 32
Trenton limestone 21
Triassic red beds 9
why unproductive 41, 42
Tunkhannock, wells near 41
Unconformity 14, 15
Unionville pool 56
United States, petroleum production 45, 46
Utica pool 51
Vacuum pumps 25, 37
Vandergrift pool 59
Venango County, pools 50, 51
production began 33
Venice pool 61
Viscosity of oil 8
differences in 13
Volant pool 36, 50
Waltersburg pool 71
Wardwell pool 48
Warren County pools 48
Warsaw pool 60
Washington County, pools 61, 62, 63
depth to Oriskany sand 38
first oil well in 43
production increase 34, 35
Washington and Taylorsville pool 62
Water, increase recovery by 33
in rocks 13
in sands 14
relation to structure 14
source of 13
Waynesburg pool 70
Webster pool 68
Wells, initial production 35
new, kinds of 38
number drilled 35
percentage dry 35
productive oil 34
Wesley pool 51
West Finley pool 63
West Hickory pool 52
West Liberty pool 54
Westmoreland County pools 67, 68
West Newton pool 68
West Virginia, oil distillates 8
specific gravity of oil 8
Wetmore pool 49
White Ash pool 66
Wildcat drilling 12, 26
Wildwood pool 64
Willett pool 61

Page.

Windfall pool 49
Winfield pool 56
Wolf Creek pool 50
Woodruff pool 69
World, petroleum production 46
Wyoming County, wells in 41
Zelienople pool 54
Zollersville pool 63


LAKE ERIE
NEW YORK
PART OF TIOGA COUNTY
PART OF TIOGA COUNTY
PART OF CLINTON COUNTY
ERIE
WARREN
CRAWFORD
FOREST
MCKEAN
CAMERON
VENANGO
MERCER
CLARION
JEFFERSON
CLEARFIELD
LAWRENCE
BUTLER
ARMSTRONG
INDIANA
BEAVER
ALLEGHENY
CAMBRIA
WESTMORELAND
WASHINGTON
FAYETTE
SOMERSET
GREENE
OHIO
WEST VIRGINIA
MARYLAND
EXPLANATION
Oil field
Gas field
Structure contours
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF INTERNAL AFFAIRS
JAMES WOODWARD SCHEETZ, SECRETARY
BUREAU OF TOPOGRAPHIC AND GEOLOGICAL SURVEY
DAVID WILLEY, STATE GEOLOGIST
IN COOPERATION WITH
DEPARTMENT OF THE INTERIOR
HUBERT WORK, SECRETARY
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR
OIL AND GAS FIELDS OF WESTERN PENNSYLVANIA
STRUCTURE CONTOURS ON HORIZON OF PITTSBURGH COAL
SCALE
15 MILES
CONTOUR INTERVAL 100 FEET
Datum is mean sea level
1920
Drawn by O.P. Stidham

DISTANCE FROM PITTSBURGH COAL HORIZON TO— (B. I. IK, 1st M IK, 2, 100' IK, 30' IK, G. S. IK, 3rd G IK, 4th IK, 5th IK, 6th-Bd IK, Elk IK, Gibbs IK, Clarion IK, Brad IK, Elk IK, Group IK)

MAP NO.	FIELD OR POOL	Type	Production Initial	Date	Prod. Sand	Distance from Pittsburgh Coal Horizon (as legible)
	ERIE COUNTY					
1	Fairview,	Gas	Small	1860	Portage	[illegible]
2	Erie,	Gas	Small	1860	Portage	[illegible]
3	Northeast,	O & G	Small	1865	Portage	[illegible]
	WARREN COUNTY					
4	Grand Valley	Oil	50-100B	1865	1, 2 & 3	1610 20 1265 2 1270 30 ... 1540 40
5	Enterprise,	Oil	5-150B	1865	1 & 3	1270 20 ... 1500 40
6	Tidioute,	Oil	10-300B	1860	2, 3 & 4	1250 ... 1460 30 ... 1520 40
7	Fagundus,	Oil	8B	1870	2 & 3	1350 10 ... 1570 10
8	Dennis Run,	Oil	25B	1867	3rd	1220 45 1340 15 ... 1600 20
9	No. Warren,	O & G	15-100B	1873	Glade	2410 20
10	Glade Run,	Oil	5-100B	1875	Glade	2410 40
11	Watwood?,	Oil	20B	1875	Cl	3000 20
12	Clarendon,	Oil	20B	1878	do	2100 12 2430 30
13	Dewdrop?,	Oil	Small	1880	do	2500 24 2610 20
14	Kinzua?,	Gas	20 Mill	1878	do	2410 15 2600 20
15	Cornplanter,	Oil	10 Small	1878	Brad.	5000 20
16	Cherry Grove,	O & G	Small	1880	Cl.	2410 25 2620 20
	McKEAN COUNTY					
17	Lafayette,	Oil	10-200B	1877	Cl	2150 10 2420 10
18	Windfield?,	Oil	Small	----	Brad.	2400 40 ... 2500 25
19	Sugar Run,	Oil	Small	1875	Dewdrop	2400 40 ... 2500 20
20	... Run,	Gas	...	1870	Brad.	3000 20
21	Bradford,	Oil	1000B	1871	Brad.	3000 20 3200 20 2450 40
22	Kendall?,	Oil	26B	1878	Brad.	5000 20 3200 10
23	Ormsby,	O & G	Small	1880	Brad.	5000 40
24	Wrigden?,	O & G	Small	1879	Brad.	3000 10 3120 25
25	Kane,	O & G	150-200	1878	Brad.	5000 10 ... 3400 10
26	Hazelhurst,	O & G	Small	1878	Brad.	3000 40 3200 25 3350 20
27	Marvindale?,	Gas	Small	1878	Brad.	1500 20 ... 3000 20
28	Smethport,	Gas	250,000	1875	Brad.	3000 40 3500 40
29	Crosby?,	Gas	Small	1880	Brad.	3000 30 3535 15
30	Bolivar?,	Gas	Small	1880	Brad.	3000 30
	POTTER COUNTY					
31	Shinglehouse,	Gas	Small		Brad	3100 20
32	Coudersport,	Gas	400 Mm.	1880	Brad	3140 20
	TIOGA COUNTY					
33	Gaines,	Oil	...	1884	Brad.	[illegible]
34	Knoxville,	Gas	...	1917		[illegible]
	CRAWFORD COUNTY					
35	Lake Creek,	Oil	5-10B	1877	1, 2 & 3	1540 15 1770 10 ... 1850 3
36	Titusville,	Oil	25B	1859	1 & 3	1500 10 1750 55 ... 1850 10
37	Atlantic,	Oil	1-5B		Berea	1425 10
38	Geneva,	Gas	Small	1800	Berea	1450 20
	MERCER COUNTY					
39	Greenville,	O & G	Small		Berea	1400 15
40	Mercer,	Oil	Small		Berea	1410 10
41	Sandy?,	O & G	1-5B	1900	Berea	1400 40
42	[illegible]	O & G	25B	1901	M & 100'	1000 170 1400 ... 1700
43	Wolf Creek,	Gas	Small		2nd	1050 130 1565 10
	VENANGO COUNTY					
44	[illegible],	Oil	Good	1870	3 & 100'	1790 40 ... 1910 30
45	Emlenton?,	O & G	Small	1875	2 & 3	1000 200 1150 50 1645 25 ... 2100 10 2175 ... 2310 100 ... 2100 10 ... 2115 10 2155 10
46	[illegible]	O & G	25	1875	2 & 3	1000 200 1150 40 1540 60 ... 2160 12 2150 ... 2380 110 ... 2000 10 ... 2010 20
47	Foxburg?,	Oil	Good	1870	2 & 3	1910 40
48	Oil City,	Oil	500B	1860	2 & 3	1620 50 1820 25 ... 1910 10
49	[illegible],	Oil	6-200B	1867	2 & 3	1600 50 1660 25 1745 25 ... 1995 35
50	Pleasantville,	Oil	3 200B	1865	3rd	1665 40 1700 25 ... 1900 25
51	Pithole,	Oil	Small	1865	3rd	1900 25
52	[illegible],	Oil	6-50B	1867	3 & 4	1775 25 ... 1930 25
53	[illegible],	Oil	2-10B	187_	3rd & 4	1900 25
54	Sandy Creek,	O & G	...	1870	3rd & Sp.	1660 40 1910 40 ... 1900 30
55	[illegible] Run,	O & G	200B	1875	1, 2, & Sp.	1570 40 1900 40 ... 1925 30 ... 2300 20
56	[illegible],	Oil	Small	1870	Sp & 3rd.	1050 160 1500 20 1780 20 1931 20 ... 2050 30
57	Utica,	Oil	Small	1874	3 & 4	1500 20 1800 10 ... 1905 40
58	Sugar Creek,	O & G	3 200B	1871	3 & 4	1645 10 ... 1880 25
59	Franklin,	Oil	Mudrods?	1860	1st	1615 20
60	Wesley,	Gas	200 H.P.		1st	1050 160 1600
	FOREST COUNTY					
61	[illegible],	Gas	...	...	3rd	1500 20 1810 10 ... 1780 25 1850
62	Marienville,	Gas	...	1881	3rd	1500 ... 1850 15
63	Clarington,	Gas	...	...	Brad., Elk	2000 ... 2100 10 2405 15
64	West Hickory,	Oil	Small	1870	1 & 3	1500 20 ... 1840 25
65	Tionesta,	Oil	10B	1871	1 & 3	1650 25 ... 1850 20
66	[illegible],	Gas	Small		3 & 4	1875 10 ... 1910 10
67	[illegible],	O & G	1000B	1881		1930 10 ... 2510 20
	ELK COUNTY					
68	[illegible],	Gas	5 Mill.	1894	Sp. & Brad	1600 12 ... 2037 20 ... 2640 20
69	Ridgway,	Gas	10 Mill.	1877	Brad.	2050 25 ... 2520 15
70	[illegible],	O & G	1 Mill	1883	Brad.	2040 30
71	[illegible],	O & G	Small	1881	Brad	2070 20 2100 40 2200 25
72	Mill Creek,	Gas	1 Mill.	1882	Brad.	2020 15 2355 20 2410 20
73	Glen Hazel,	O & G	[illegible]	1885	Kane	2400 10
74	Bear Creek,	Gas	2 Mill	1885	Brad.	2000 45 2285 15
75	Saint Marys,	O & G	Small	1890	Elk	2600 15
	CLINTON COUNTY					
76	Hammersley Fork	Gas	1 Mill.	1899		[illegible]
	LAWRENCE COUNTY					
77	[illegible],	Oil	2B	1919	Berea	1400 10
78	Mt. Jackson,	Gas	100,000'	1901	Berea	1450 15
79	[illegible] Valley,	Gas	Small		Berea	1450 20
80	New Castle,	Gas	Small	1900	Berea	1400 10
81	Princeton,	Gas	100,000'		Berea	[illegible]
82	Slippery Rock	Oil	Small	1890	Berea	1400 10
83	Camp Run,	O & G	Small	...	Berea	1440 20
	BEAVER COUNTY					
84	New Galilee,	Oil	10B	1862	Berea	1400 40
85	Brady's Run,	Gas	3 Mill	1861	& 100'	1000 100 1400 60 1720 50
86	[illegible] Ferry,	Oil	1-5B	1860	Berea	1440 20 1725 20
87	Hookstown,	Oil	200B	1899	Berea	1140 10 1420 40 1700 60
88	New Sheffield,	O & G	25 Mill	1891	100'	1110 70 1440 170 1710 10 1750 10
89	[illegible],	Oil	100-200B	1862	100'	1440 100 1720 25
90	[illegible],	O & G	1000	1876	100'	1400 70
91	[illegible],	O & G	Small	1877	100'	1700 60
92	Crows Run,	O & G	Small	1897	100'	1700 60 1860 5 ... 2350
93	Monaca,	O & G	Small	1917	100' & 30'	1000 100 ... 1440 20
	BUTLER COUNTY					
94	[illegible],	Gas	Small	...	100'	1800 40
95	West Liberty,	O & G	1 Mill.	1870	M & 100'	1050 200 1620 15 1830 40
96	Muddy Creek,	Oil	...	1861		1100 200 1600 15 1810 60
97	[illegible],	O & G	25B	1900	100'	1800 115 2000 15 2050 10 2100 15
98	[illegible],	Oil	Small	1900	100' & 4	1840 110 ... 2100 10
99	Thorn Creek	O & G	Small	1890	100', 3 & 4	1600 1810 100 1850 25 2090 10 2100 10 2140 15
100	Butler,	Gas	Small	1892	100' & 4	1650 20 1770 110 ... 2000 10 2150 20
101	Glade Mills,	Oil	Small	17_	100' & 4	1780 80 ... 2090 10
102	Evans City,	Oil	200B	1892	100' & ...	1800 100 ... 2010 10
103	[illegible],	Oil	Small	...	100'	1800 40
104	Callery,	Oil	Small	1890	100'	1750 60
105	[illegible],	O & G	212 B	1897	M, 100' & G	1100 40 1640 ... 1800 75
106	[illegible],	O & G	[illegible]	1899	100' & 4th	1810 60
107	[illegible],	Oil	5B	1895	100'	1700 80
108	Mars,	Oil	Small	1895	100'	1700 100
109	[illegible],	O & G	Small	1890	5 & 100'	1125 140 ... 1800 65 ... 2090 5 2150 5 2300 50 ... 2015 10
110	[illegible],	O & G	Small		5 & 100'	1100 200 ... 1800 60 ... 2050 10 2100 10 ... 2100 20
111	[illegible],	O & G	15B	1896	100' & 3	1600 60 ... 2050 10
112	N. Washington,	O & G	Small	1894	100' 3 & Sp.	1800 110 2000 20 ... 2050 5 2110 20 2165 25 ... 2100 20
113	Petrolia,	O & G	20B	1872	3 4 & Sp	1070 200 1820 90 1900 100 1940 25 2040 10 2090 10 2110 20 2170 20 ... 2020 20
114	[illegible]	O & G	300B	1874	4th	1150 ... 1800 100 1900 15 1960 20 2040 20 2110 20 2160 10 ... 2015 15
115	Concord,	O & G		1872	4 & Sp.	1150 ... 1800 110 1950 15 1990 20 2055 10 2125 25 ... 2010 10
116	[illegible],	O & G	500 H.P.	1902	Sp.	2040 20
117	[illegible] Run,	Oil		1860	100' & Sp	1800 150
118	[illegible],	O & G	100 H.P.	1885	100', 3 & Sp	1700 90 1900 20 2040 10 ... 2000 20
119	[illegible],	O & G	Good	1895	5, 4 & Sp.	1140 140 1600 150 1700 50 1935 25 2040 10 2070 30 2110 60 2175 15 ... 2040 25
120	Saxonburg,	O & G	Good	1880	4 & 5	1600 150 1800 100 1965 25 2050 10 2090 20 2120 15 2270 20
121	[illegible],	O & G	Good	1897	5 & 100'	1100 215 1665 90 1830 40 1900 20 ... 2110 20
122	Clinton Twp	Gas	Good	1900	Sp	1100 200 1665 60 1805 100 1950 45 2000 10 2095 45 2125 25 2165 15 2240 20 ... 2000 10
123	Winfield,	Gas	Small	1915	1 2 & 5	1120 200 1600 100 1790 60 2010 30 2090 30 2120 30 2150 45 2215 25
	CLARION COUNTY					
124	[illegible],	O & G	Small		4 & Sp	1870 25 ... 2080 10 2060 15 ... 2850 20
125	[illegible],	O & G	21 Mill.		M 100', Sp	1100 100 1870 40 ... 2040 20 ... 2015 15
126	Elk City,	O & G	20B	1890	3, 4 & Sp	1850 15 ... 2050 20 2200 40
127	[illegible]	Gas			5 & Sp	1750 20 1810 40 ... 2010 40 ... 2010 20 2100 25 2255 15
128	[illegible],	O & G	Small	1870	100' & Sp.	1700 20 1880 20 ... 2000 10 2170 20 ... 2100 40
129	[illegible],	Gas	Small	1870	3 & Sp	1800 20 ... 2000 5 2100 15 ... 3420 30
130	Pine Grove,	Gas	Small	1870	Sp. & M	1150 270 1600 25 1760 20 ... 2100 20
131	Lucinda	Gas	Small	1870	Brad	2200 10 ... 3420 25
132	[illegible]	O & G	Small	1900	2 & 4	2000 10 2240 20

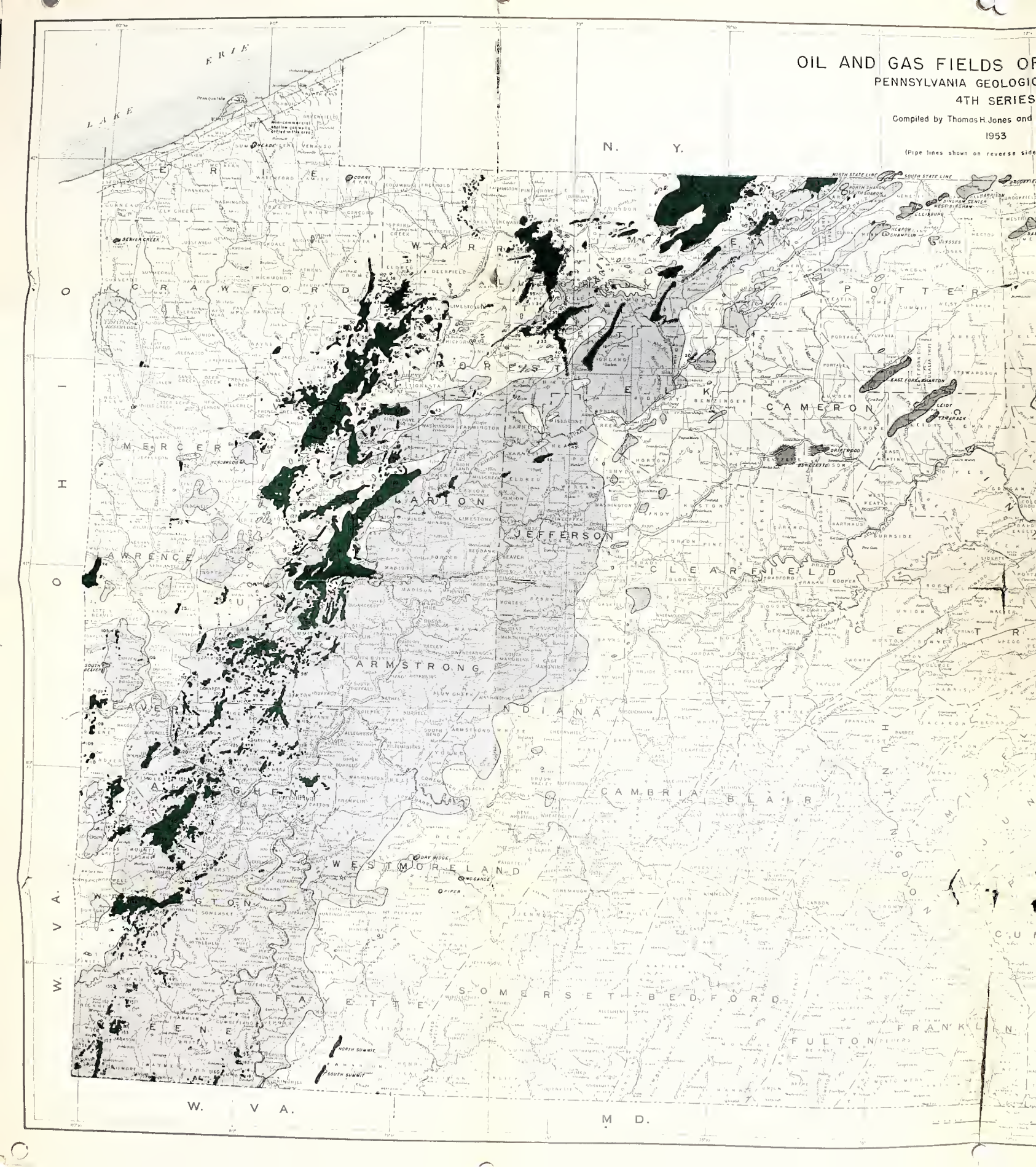
KEY TO SYMBOLS.

B. I.	Big Injun Sand	30'	Thirty Foot Sand	6	Sixth Sand	B	Barrel
IK	Thickness	G. S.	Gordon Stray Sand	Bd	Bayard Sand	R. P.	Rock Pressure
1	First Sand	3	Third Sand	Elk	Elizabeth Sand	Ka	Kane Sand
M	Murrysville Sand	G	Gordon Sand	Sp	Speechley Sand	Ti	Tiona
2	Second Sand	4	Fourth Sand	Brad	Bradford Sand		
100'	One Hundred Foot Sand	5	Fifth Sand	Small	Small Production		

MAP NO.	FIELD OR POOL	Type	Production Initial	Date	Prod. Sand	Distance from Pittsburgh Coal Horizon
	CLARION COUNTY (Cont'd)					
133	Clarion,	O & G	...	1886	4 & Sp.	[illegible]
134	[illegible],	O & G	50B	1886	100', 4 & Sp	[illegible]
135	Sligo,	Gas	Small	1914	100'	[illegible]
136	[illegible],	Gas	½ Mill	...	Sp.	[illegible]
137	Greenville,	Gas	1 Mill	...	100' M & [illegible]	[illegible]
138	[illegible],	Gas	100,000'	...	100', Brad.	[illegible]
139	Mill Creek,	Gas	Small	...	M	[illegible]
140	Cherry Run,	Gas	...	1860	100' & 30'	[illegible]
141	[illegible] Run,	Gas	...	...	4th	[illegible]
142	Catfish Run,	Gas	...	1890	100' & 4	[illegible]
143	[illegible],	Gas	Small		4th	[illegible]
144	[illegible],	Gas	Good	1902	100' & 4	[illegible]
145	[illegible],	Gas	Small	1902	100', 4, Sp.	[illegible]
146	[illegible],	Gas	½ Mill.		M & Sp.	[illegible]
147	New Bethlehem	O & G	Small	1917	100' & 4	[illegible]
148	[illegible],	O & G	1 M & 100B	1876	100' Sp. &c	[illegible]
	ARMSTRONG COUNTY					
149	[illegible],	Gas	Small	1875	100', 4 & Sp.	[illegible]
150	French Corners,	Gas	1 Mill.	1878	100' & Sp	[illegible]
151	Limestone Run,	Gas	...	1876	100' & Sp.	[illegible]
152	North Buffalo,	Gas	½ Mill		3rd & Sp	[illegible]
153	Slate Lick,	Gas	400 lb.		Sp	[illegible]
154	Freeport,	Gas	Good		M & Sp	[illegible]
155	Madison,	Gas	250 H.P.	1875	4 & Sp.	[illegible]
156	Mahoning Furnace,	Gas	1 Mill.	1876	M, 100' & Sp.	[illegible]
157	Little Mahoning Cr.	Gas	½ Mill.	1894	M, 100', 30'	[illegible]
158	New Salem,	Gas	½ Mill.	1894	M 3rd & Sp	[illegible]
159	McCrea Furnace	Gas	½ Mill.	1878	30' & Sp.	[illegible]
160	[illegible],	Gas	12 Mill.	1914	Sp	[illegible]
161	Cowanshannock,	Gas	½ Mill	1875	5 & Sp	[illegible]
162	Ford City,	Gas	Small		M Sp. & Ti	[illegible]
163	[illegible],	Gas	Small	1890	M & 100'	[illegible]
164	Atwood,	Gas	Small		M & 100'	[illegible]
165	[illegible],	Gas	Small	1907	M & 100'	[illegible]
166	[illegible],	Gas	Small		100' & 5	[illegible]
167	[illegible],	Gas	Small	1911	M & 100'	[illegible]
168	Vandergrift,	Gas	H.P. 315		5 & Brad.	[illegible]
169	[illegible],	Gas	Small	1890	100' & Brad.	[illegible]
170	Girty,	Gas	Small	1891	M & 100'	[illegible]
171	Plum Creek	Gas	½ Mill.	1890	M & Brad	[illegible]
172	[illegible] Run,	Gas	Small	1891	100' & Brad	[illegible]
173	Apollo,	Gas	½ Mill.	1900	Sp. & Brad.	[illegible]
	JEFFERSON COUNTY					
174	[illegible],	Gas	Small	1900	Sp. & Brad.	[illegible]
175	[illegible],	Gas	Small		Kane	[illegible]
176	[illegible],	Gas	...		M	[illegible]
177	Warsaw,	Gas	5 Mill.	1916	Sp. & Elk.	[illegible]
178	Brookville,	Gas	3 Mill.	1884	Kane	[illegible]
179	[illegible],	Gas	Small		4th	[illegible]
180	North Point,	Gas	...		100', 30' & Sp.	[illegible]
	INDIANA COUNTY					
181	[illegible],	Gas	...	1885	1, 2, 3 & Sp.	[illegible]
182	[illegible],	Gas	Small		G & Kane	[illegible]
183	Willet,	Gas	H.P. 275	1909	M & Sp.	[illegible]
184	Creekside,	Gas	H.P. 325	1900		[illegible]
185	Strongstown,	Gas	Small			[illegible]
	CAMBRIA COUNTY					
186	Cherrytree,	Gas	Small	1895		[illegible]
187	Carrolltown,	Gas	Small	1900	Sp.?	[illegible]
188	Belsano,	Gas	15,000	1918	Sp.?	[illegible]
	WASHINGTON COUNTY					
189	Florence,	O & G	200 B	1860	100'	[illegible]
190	[illegible],	Gas	H.P. 100	1890	100'	[illegible]
191	Burgettstown,	O & G	200 B	1890	100'	[illegible]
192	McDonald,	Oil	10,000 B	1890	3, 4 & 5	[illegible]
193	Venice,	Oil	1000 B	1890	100', 3, 4, 5	[illegible]
194	Hickory,	Gas	20 Mill.	1882	100', 3, 4, 5	[illegible]
195	Canonsburg,	O & G	200 B	1884	100', 3, 4, 5	[illegible]
196	Buffalo,	Gas	H.P. 400	1887	B.I., 3 & 4	[illegible]
197	Linden,	O & G	550 B	1900	100' & 5	[illegible]
198	Finleyville,	O & G	100 B	1890	5th	[illegible]
199	[illegible],	Gas	1250	1900	100' & 3	[illegible]
200	Wash. & Taylorstown,	Oil	1000 B	1885	100', 3, 4, 5	[illegible]
201	Lagonda,	O & G	Good	1890	B.I., 100' &c.	[illegible]
202	[illegible],	O & G	10 Mill.	1900	4 & Elk.	[illegible]
203	Somerset,	Gas	10 Mill.		B.I., 100' &c.	[illegible]
204	West Finley,	O & G	Good		B. I.	[illegible]
205	[illegible],	O & G	400 B	1896	B.I., 3, 4, &c	[illegible]
206	Amity,	Gas	2 Mill.		B. I.	[illegible]
	WASHINGTON COUNTY (Cont'd)					
207	Lone Pine,	Gas	2 Mill.	New	3 & 4	[illegible]
208	[illegible],	Gas	1 Mill.	New	100' & 4	[illegible]
209	Zollarsville,	Gas	Small	1902	Elk.	[illegible]
210	[illegible],	Gas	4-5 Mill	1897	B. I., 100', 3, 5	[illegible]
	ALLEGHENY COUNTY					
211	[illegible],	Gas	1 Mill.		100' 30'	[illegible]
212	McMurry,	O & G	12 B		Elk, 100', &c.	[illegible]
213	[illegible],	Gas	600 H.P.		4th	[illegible]
214	[illegible],	O & G			100' & 4	[illegible]
215	[illegible],	Oil	100 B	1891	30' & 5	[illegible]
216	Coraopolis,	O & G	100 B	1890	30' & 4	[illegible]
217	[illegible],	O & G	Small	1891	100', 3 & 4	[illegible]
218	Imperial,	O & G	100 B	1896	100' & G.B.	[illegible]
219	Moon Run,	O & G	[illegible]	1890	3 & 5	[illegible]
220	McCurdy,	O & G	600 B	1900	100', 5 & 30'	[illegible]
221	Brush Creek,	O & G	1 Mill	1887	100', 5 & 3	[illegible]
222	[illegible],	O & G	1 Mill	1890	100', 3 & 4	[illegible]
223	[illegible],	O & G	2 Mill.	1895	5	[illegible]
224	Glenfield,	O & G	100 B	1895	100' & 4	[illegible]
225	Wildwood,	Oil	1000 B	1890	3 & 4	[illegible]
226	[illegible],	O & G	Small	1890	100' & 5	[illegible]
227	Bellevue,	O & G	Small	1895	100', 30', 3, 5	[illegible]
228	Carnegie,	O & G	Small	1900	100' & 5	[illegible]
229	[illegible],	O & G	Small	1905	100', 4 & 5	[illegible]
230	Bridgeville,	Gas	1½ Mill.	1900	5 & 30'	[illegible]
231	Clifton,	O & G	Small	1897	B.I., 100', 5	[illegible]
232	Deer Creek,	O & G	100 B	1900	30' & 4	[illegible]
233	Allison Park,	O & G		1890	30' & 3	[illegible]
234	Tarentum,	Gas	Small	1878	4 & Sp.	[illegible]
235	Plum Twp	O & G	100 B	1900	100', 5 & Sp.	[illegible]
236	Homewood & Swissvale,	Gas	Small	1884	M, 5 & Sp.	[illegible]
237	White Ash,	O & G	10 B	1910	5 & Sp	[illegible]
238	[illegible],	Gas	Small	1917	100' & Elk.	[illegible]
239	Homestead,	Gas	2 Mill.	1884	100', & Sp.	[illegible]
240	Mifflin,	Gas	Small	1915	100', 5 & B	[illegible]
241	[illegible],	Gas	H.P. 300	1891	B.I., & 100'	[illegible]
242	Elizabeth,	Gas	Good	1890	5th, Sp., Elk.	[illegible]
243	McKeesport,	Gas	22 Mill.	1919	Sp.	[illegible]
244	Lincoln,	Gas	5 Mill	1919	Sp. B.I., Elk.	[illegible]
245	Forward,	Gas	6 Mill.	1900	100' & 4	[illegible]
	WESTMORELAND COUNTY					
246	[illegible],	Gas	Small	1910	4 & Sp.	[illegible]
247	[illegible],	Gas	Small	1900	100' & Brad.	[illegible]
248	Murrysville,	Gas	25 Mill.	1878	M & Sp.	[illegible]
249	Bell Twp.,	Gas	Small		100'	[illegible]
250	[illegible],	Gas	Small	1900	M & 100'	[illegible]
251	Delmont,	Gas	6 Mill	1901	6, 4 Elk, Sp.	[illegible]
252	Grapeville Area	Gas	4 Mill.	1900	100', 5, Sp. &c	[illegible]
253	Latrobe,	Gas	1 Mill.	1907	100'	[illegible]
254	Pleasant Unity,	Oil	Small	1890	100'	[illegible]
255	McCance,	Gas	1 Mill.	1890	Oriskany	[illegible]
256	[illegible],	Gas	6 Mill	1911	100' & B.I.	[illegible]
257	West Newton,	Gas	4 Mill.	1898	100' & B.I.	[illegible]
258	Webster,	Gas	4-5 Mill.	1887	100', B.I., 5	[illegible]
	GREENE COUNTY					
259	[illegible],	O & G	1000 B	1907	100', 3 & 4	[illegible]
260	Aleppo,	O & G	25 Mill.	1900	G.S. 100', 3, 4	[illegible]
261	[illegible],	O & G	3 Mill	1896	G.S., 30', 3, 4	[illegible]
262	[illegible],	O & G	600 B	1900	B.I., 5 &c	[illegible]
263	New Freeport,	O & G	11 Mill.	1900	30', 100' 3, 4	[illegible]
264	[illegible],	Gas	2 Mill	1906	100' & 3	[illegible]
265	[illegible],	O & G	7 Mill	1890	B.I., 5 & 6	[illegible]
266	Waynesburg,	Gas	60 Mill.	1889	5, 6, Elk.	[illegible]
267	[illegible],	Gas	1 Mill.		5th & B.I.	[illegible]
268	Carmichaels,	O & G	3 Mill.	1864	5, 100', Elk.	[illegible]
269	[illegible],	Oil	60 B	1870	Dunkard	[illegible]
270	Mt. Morris,	O & G	200 B	1886	B.I. & 4	[illegible]
271	Blacksville,	O & G	100 B	1885	B.I. & 100'	[illegible]
272	[illegible],	O & G	25 B	1890	B.I. G.B. 30'	[illegible]
273	Grays Fork,	O & G	600,000	1907	3, 4, 30'	[illegible]
	FAYETTE COUNTY					
274	[illegible],	Gas	14 Mill.		B.I., 100', G.B.	[illegible]
275	Antrim Run,	Gas	12 Mill.		G.B.	[illegible]
276	[illegible]	Gas	2 Mill.		B.I. & Sp.	[illegible]
277	[illegible]	Gas	Small	1900	B.I. & 100'	[illegible]
278	Masontown,	Gas	1 Mill	1904	B.I. & 100'	[illegible]
279	Fayette,	O & G	20 B	1907	B.I.	[illegible]
280	New Geneva,	O & G	10 B		B.I. & 100'	[illegible]

KEY TO SYMBOLS.

B. I.	Big Injun Sand	30'	Thirty Foot Sand	6	Sixth Sand	B	Barrel
IK	Thickness	G. S.	Gordon Stray Sand	Bd	Bayard Sand	R. P.	Rock Pressure
1	First Sand	3	Third Sand	Elk	Elizabeth Sand	Ka	Kane Sand
M	Murrysville Sand	G	Gordon Sand	Sp	Speechley Sand	Ti	Tiona
2	Second Sand	4	Fourth Sand	Brad	Bradford Sand		
100'	One Hundred Foot Sand	5	Fifth Sand	Small	Small Production		


OIL AND GAS FIELDS OF
PENNSYLVANIA GEOLOGIC
4TH SERIES
Compiled by Thomas H. Jones and
1953
(Pipe lines shown on reverse side
LAKE ERIE
N. Y.
O H I O
W. VA.
W. VA.
M D.
ERIE
CRAWFORD
WARREN
MCKEAN
POTTER
FOREST
ELK
CAMERON
MERCER
VENANGO
CLARION
JEFFERSON
CLEARFIELD
CENTRE
LAWRENCE
BUTLER
ARMSTRONG
INDIANA
CAMBRIA
BLAIR
ALLEGHENY
WESTMORELAND
WASHINGTON
GREENE
FAYETTE
SOMERSET
BEDFORD
FULTON
FRANKLIN
Miscommercial shallow gas wells drilled in this area
CORRY
WARREN
TIDIOUTE
YOUNGSVILLE
SHEFFIELD
CLARENDON
SHERIFFS
BRADFORD
DUKE CENTER
SMETHPORT
KANE
ST MARYS
RIDGWAY
DU BOIS
PUNXSUTAWNEY
INDIANA
KITTANNING
ELLWOOD CITY
NEW CASTLE
BUTLER
GREENSBURG
UNIONTOWN
CONNELLSVILLE
JOHNSTOWN
ALTOONA
HOLLIDAYSBURG
BEDFORD
SOMERSET
CONFLUENCE
OHIOPYLE
OIL CITY
FRANKLIN
TITUSVILLE
MEADVILLE
CONNEAUT
ASHTABULA
NORTH EAST
GIRARD
WARREN
YOUNGSTOWN
SHARON
FARRELL
SHENANGO
NEW CASTLE
BEAVER FALLS
ROCHESTER
MONACA
ALIQUIPPA
PITTSBURGH
MCKEESPORT
WASHINGTON
CANONSBURG
MONONGAHELA
CHARLEROI
MONESSEN
GREENSBURG
LATROBE
JOHNSTOWN
ALTOONA
HOLLIDAYSBURG
BEDFORD
SOMERSET
CONFLUENCE
OHIOPYLE
CONNELLSVILLE
UNIONTOWN
WAYNESBURG
MASONTOWN
NORTH SUMMIT
SOUTH SUMMIT
OIL CITY
FRANKLIN
TITUSVILLE
MEADVILLE
CONNEAUT
ASHTABULA
NORTH EAST
GIRARD
WARREN
YOUNGSTOWN
SHARON
FARRELL
SHENANGO
NEW CASTLE
BEAVER FALLS
ROCHESTER
MONACA
ALIQUIPPA
PITTSBURGH
MCKEESPORT
WASHINGTON
CANONSBURG
MONONGAHELA
CHARLEROI
MONESSEN
GREENSBURG
LATROBE
JOHNSTOWN
ALTOONA
HOLLIDAYSBURG
BEDFORD
SOMERSET
CONFLUENCE
OHIOPYLE
CONNELLSVILLE
UNIONTOWN
WAYNESBURG
MASONTOWN
NORTH SUMMIT
SOUTH SUMMIT

FIELDS OF PENNSYLVANIA

VANIA GEOLOGICAL SURVEY

4TH SERIES

by Thomas H Jones and Lillian Heeren

1953

s shown on reverse side of this map)

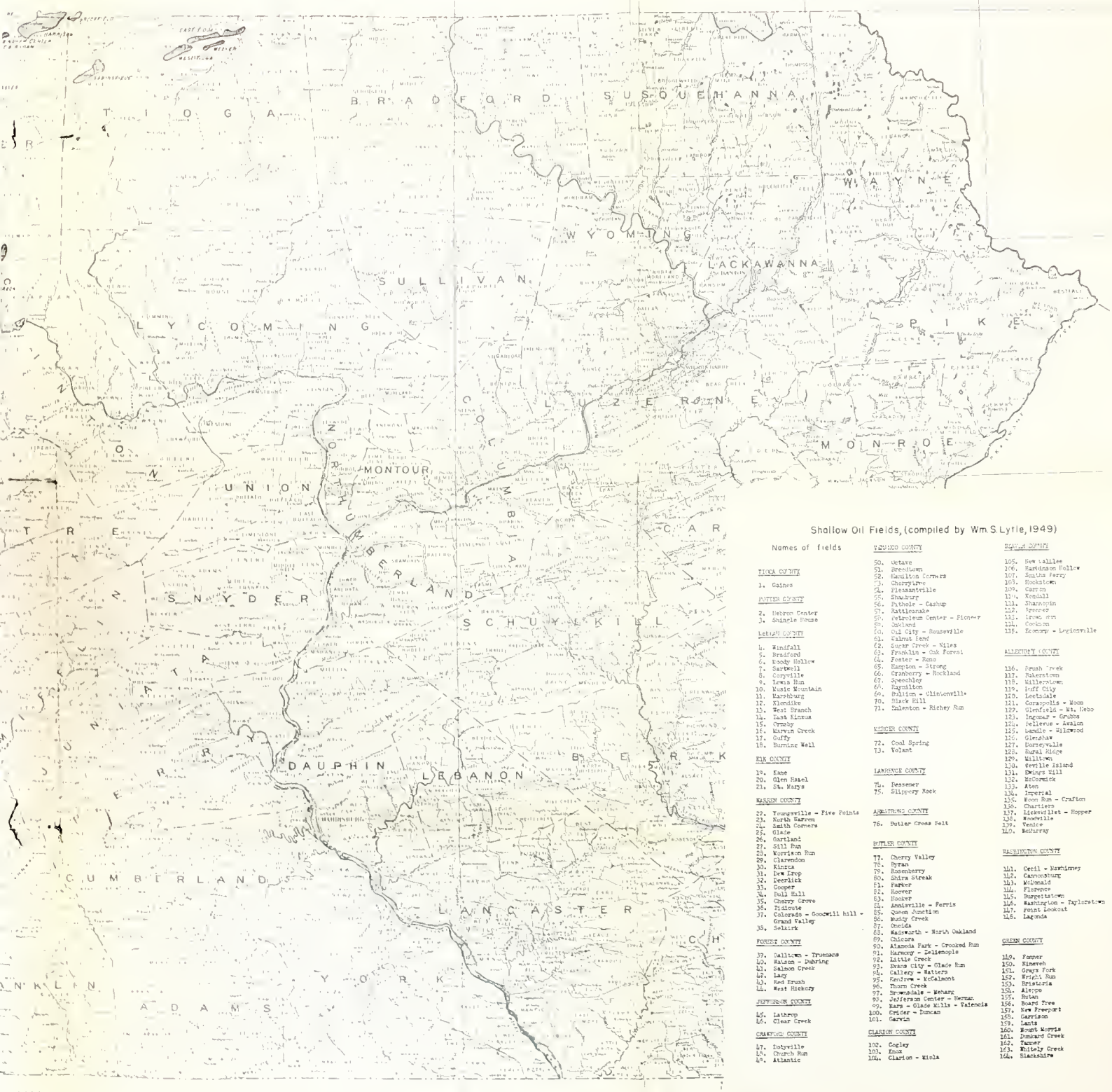
EXPLANATION

Shallow Oil Field

Area of shallow gas

Deep Gas Field (Onondaga and deeper)

Acknowledgment: All oil and gas field outlines are from publications of the Pennsylvania Geological Survey and from Oil and Gas Companies



Shallow Oil Fields, (compiled by Wm. S. Lytle, 1949)

Names of fields

TIOGA COUNTY

1. Gaines

POTTER COUNTY

2. Hebron Center
3. Shingle House

LYCOMING COUNTY

4. Windfall
5. Bradford
6. Woody Hollow
7. Sartwell
8. Coryville
9. Lewis Run
10. Music Mountain
11. Hareshburg
12. Klondike
13. West Branch
14. Lank Kinnan
15. Ormsby
16. Marvin Creek
17. Duffy
18. Burning Well

KIA COUNTY

19. Kane
20. Glen Hazel
21. St. Marys

MARION COUNTY

22. Youngsville - Five Points
23. North Warren
24. Smith Corners
25. Glade
26. Garland
27. Hill Run
28. Morrison Run
29. Clarendon
30. Kinzua
31. Dew Drop
32. Deerlick
33. Cooper
34. Doll Hill
35. Cherry Grove
36. Tidioute
37. Colorado - Goodwill Hill - Grand Valley
38. Selkirk

FOREST COUNTY

39. Dalltown - Truemans
40. Watson - Dunbrig
41. Salmon Creek
42. Lazy
43. Red Brush
44. West Hickory

JEFFERSON COUNTY

45. Lathrop
46. Clear Creek

CRAWFORD COUNTY

47. Dotyville
48. Church Run
49. Atlantic

VENANGO COUNTY

50. Octave
51. Breedtown
52. Hamilton Corners
53. Cherrytree
54. Pleasantville
55. Shawbury
56. Pathole - Cashup
57. Rattlesnake
58. Petroleum Center - Pioneer
59. Oakland
60. Oil City - Rouseville
61. Walnut Bend
62. Sugar Creek - Miles
63. Franklin - Oak Forest
64. Foster - Reno
65. Hampton - Strong
66. Cranberry - Rockland
67. Speechley
68. Hamilton
69. Dullion - Clintonville
70. Black Hill
71. Emlenton - Richey Run

MERCER COUNTY

72. Coal Spring
73. Volant

LAWRENCE COUNTY

74. Bessemer
75. Slippery Rock

ARMSTRONG COUNTY

76. Butler Cross Belt

BUTLER COUNTY

77. Cherry Valley
78. Byran
79. Rosenberry
80. Shira Streak
81. Parker
82. Hoover
83. Hooker
84. Annisville - Ferris
85. Queen Junction
86. Muddy Creek
87. Cheida
88. Wadsworth - North Oakland
89. Chicora
90. Alameda Park - Crooked Run
91. Harmony - Zelienople
92. Little Creek
93. Evans City - Glade Run
94. Callery - Mathers
95. Renfrew - McCalmont
96. Thorn Creek
97. Brownsdale - Meharg
98. Jefferson Center - Herman
99. Mars - Glade Mills - Valencia
100. Crider - Duncan
101. Garvin

CLARION COUNTY

102. Cooley
103. Knox
104. Clarion - Niola

BEAVER COUNTY

105. New Galilee
106. Hardinton Hollow
107. Smiths Ferry
108. Hookstown
109. Garrison
110. Kendall
111. Shannopin
112. Spencer
113. Lewis Run
114. Cookson
115. Economy - Logtownville

ALLEGHENY COUNTY

116. Brush Creek
117. Bakerstown
118. Millerstown
119. Duff City
120. Meetdale
121. Corraopolis - Moon
122. Glenfield - Mt. Nebo
123. Ingomar - Crubbs
124. Bellevue - Avalon
125. Landle - Wildwood
126. Glenshaw
127. Dorseyville
128. Rural Ridge
129. Williams
130. Neville Island
131. Ewings Mill
132. McCormick
133. Aten
134. Imperial
135. Moon Run - Crafton
136. Chartiers
137. Kirkwillet - Hopper
138. Woodville
139. Venice
140. McMurray

WASHINGTON COUNTY

141. Cecil - Mawhinney
142. Carnegieburg
143. Mcdonald
144. Florence
145. Burgettstown
146. Washington - Taylorstown
147. Point Lookout
148. Lagonda

GREEN COUNTY

149. Farmer
150. Nineveh
151. Grays Fork
152. Wright Run
153. Bristoria
154. Alpha
155. Rutan
156. Board Tree
157. New Freeport
158. Garrison
159. Lantz
160. Mount Morris
161. Dunkard Creek
162. Tanner
163. Whitely Creek
164. Blackshire

Base Map prepared by Pennsylvania Topographic and Geologic Survey